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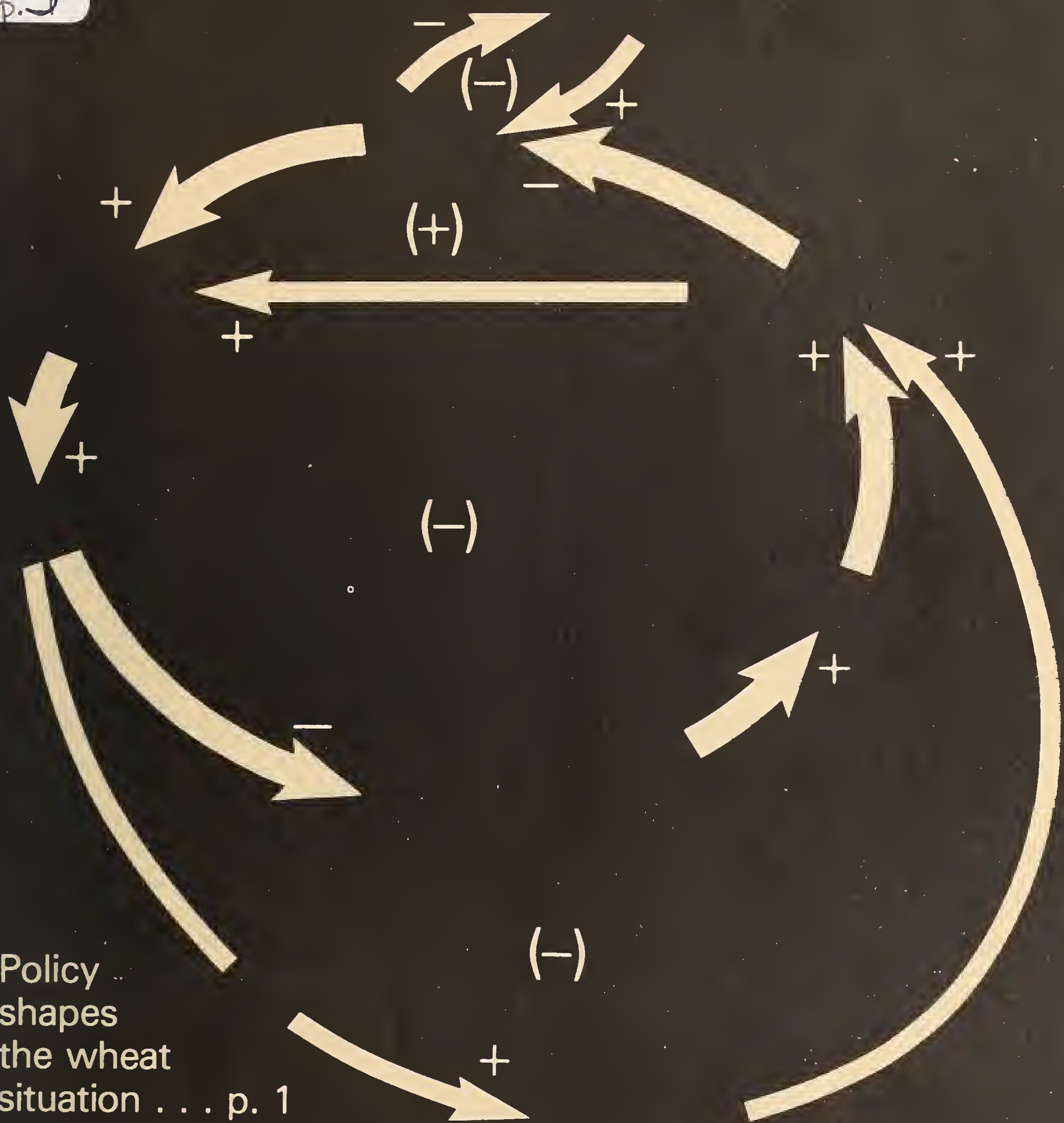

Policy shapes the wheat situation . . . p. 1

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Economic modelers of different persuasions often find it difficult to communicate with one another. And modelers of any persuasion often find it difficult to communicate with policymakers. In a recent book, *Models in the Policy Process*, Greenberger, Crenson, and Crissey state that these communication gaps call for two kinds of bridges. One needs to be built between researchers of different persuasions; the other, between researchers and policymakers. The authors illustrate the conflict among researchers by recounting the differences of opinion between adherents of the Cowles Commission school of simultaneous equations and adherents of the Systems Dynamics school of feedback loops. Contributors to this *Journal* who model the economic structure of farm commodities tend to follow the Cowles approach. However, in this issue, Brzozowski applies the Systems Dynamics approach to the U.S. wheat economy. In doing so, he may help toward building the two kinds of bridges called for by Greenberger, Crenson, and Crissey.

* * *

Insofar as an economist thinks in generalities—for example, in claiming no more than that variable (Y) is some unknown function of variable (X)—economic theory can proceed with little quibbling about details. Once a specific form for that function is selected, be it linear, quadratic, exponential, translog, or some other form, the economist may find himself or herself on the defensive concerning unexamined assumptions introduced by the choice of form. Questions raised by choice of form have been addressed by authors of three recent articles in these pages: Lin and Chang (January 1978), Buccola and French (January 1978), and Lamm (January 1979). In this issue, Salathe looks at the properties of Engel curves implied by the choice of functional form. He finds empirical as well as theoretical support for using the double-logarithmic form for Engel curves.

* * *

Some economic attributes are hierarchical: if a given attribute is present, all lower-order attributes are also present. Scaling is a procedure developed by psychologists to determine whether human attributes, such as attitudes, can be ranked hierarchically. The procedure has been subsequently used to evaluate attributes in other fields, particularly sociology. The article by Stuby illustrates how scaling can be used to evaluate the degree of rurality of counties.

* * *

I am becoming conditioned to look up the word "tautology" in my dictionary under "M" because the phrase "mere tautology" is used so often that the two words are beginning to sound like one to me. I am sensitive to this because I find tautologies important in economic thought. When we classify a statement in economics as "meretautology," we imply that it needlessly repeats an idea, usually one that is true by definition. Yet, certain observations which appear obvious, redundant, and true by definition have been turned by theorists into equations which serve as cornerstones of economic theory. Examples include the budget constraint in the theory of consumer demand, the profit equation in the theory of the firm, and the macroeconomic idea that aggregate demand equals spending by households, business, and government. Cantwell, in his article, uses a tautology concerning payments by patients and income to doctors. He points out, however, that the observation is only tautological in competitive equilibrium. It need not be valid in disequilibrium. Cantwell finds that regression coefficients for the equation which would be definitionally true in equilibrium show the extent to which divergence from equilibrium occurs in the rural-urban distribution of medical services.

CLARK EDWARDS

Contents

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A Systems Approach to U.S. Wheat Policy

By Leonard Brzozowski *

A system dynamics computer simulation model called GRAIN1 can be used to analyze public policy alternatives in the agricultural economy. American farm policy has been aimed at controlling commodity productions cyclic processes faced with many uncertainties. A systems approach such as GRAIN1, used to analyze six alternate future policies for wheat, can assist policymakers by assessing some of the critical trade offs and consequences of alternate policies.

Keywords:

System dynamics
Simulation
Wheat
Farm structure

AN HISTORICAL FRAMEWORK FOR AMERICAN FARM POLICY

A serious problem in U.S. farming has been excess production. During the first half of this century, American agriculture advanced rapidly in efficiency and productivity. Mechanization, more intensive farming practices, and achievements in agricultural research made these advances possible. Yet these advances also resulted in food surpluses and reduced farm prices and incomes.

The efforts of farmers and agricultural researchers to reduce farm costs further through greater efficiency did not entirely succeed during the first third of this century. While some productivity gains were realized, they could not offset the depressed farm commodity prices experienced during that period. Because it was not economically favorable to produce wheat, farmers shifted to other crops yielding higher market prices.

The farmers' response to these economic forces caused cycles in commodity production. When wheat prices, for example, are high, farmers plan to produce more wheat. When half a million wheat farmers increase production, however, a large surplus sends the price down. Similarly, when wheat prices fall, farmers produce less wheat, inventories decline, and wheat prices rise once again. This cyclic behavior is inherent in the production of wheat, corn, and virtually all other commodities.

As a result, farm prices are volatile and difficult to control. They tend to move both upward and downward faster than prices in other sectors of the economy. As a result, agriculture has a visibility that causes politicians, consumers, and farmers to react strongly when prices change dramatically. Such reactions tend to coincide with the oscillations of the commodity production cycle for key commodities.

For example, when the wheat production cycle was at its low point (and prices were high) 3 years ago, consumers organized boycotts of meat products in several U.S. cities. In 1978, we experienced a nationwide farmers' strike at a time when the wheat production cycle was at its peak (prices were depressed).

THE ROLE OF AMERICAN FARM POLICY

With the passage of the Agricultural Adjustment Act of 1933, the Government made a firm commitment to stabilizing the agricultural economy. Since that time, American farm policy's role has been to control commodity production's cyclic processes in the face of uncertain weather variations, export demand, and, most importantly, conflicting consumer and farmer pricing goals. American farm policymakers try to introduce balance into the production and market systems and the divergent goals through three sets of programs: supply management, demand management, and income maintenance.

Supply Management Programs

Acreage controls, diversions, and set-aside programs have the aim of limiting and controlling production and balancing it with expected demand. Under these programs, the U.S. Department of Agriculture (USDA) administers farmer-held grain reserves to absorb random variations in supply and demand and to help insure that commodities are marketed with a minimum of disruption from harvest to harvest. Under provisions of the 1977 farm bill, farmers can take a nonrecourse loan from the Government at the prevailing loan rate, using their harvested crops as collateral. When prices are low, farmers can put part of their crop into Government-paid storage

*The author is assistant to the group vice-president for mechanical controls, Midland-Ross Corporation, Cleveland, OH. The model was developed jointly by Dartmouth College and the U.S. Department of Agriculture when the author served in the Department's Office of Management and Finance.

A system dynamics computer simulation model called GRAIN1 can be used to analyze public policy alternatives in the agricultural economy. American farm policy has been to control commodity productions cyclic processes faced with many uncertainties. A system approach such as GRAIN1, used to analyze six alternate future policies for wheat policy, can assist policymakers by assessing some of the critical trade offs and consequences of alternate policies.

for 3 years. If prices rise above a predetermined level, farmers can sell their crop on the open market at a price above the loan rate. If prices continue to rise, the Government can encourage the sale of additional crops from the reserve by discontinuing the payment (subsidy) for crop storage. In extreme cases, the Government can call the loan due and acquire the remaining reserve crop for sale on the market.

Demand Management

Programs are also designed to stimulate demand for American commodities and to use supply excesses. In the past, these objectives were met by providing direct subsidies to foreign countries purchasing American crops, carrying out P.L. 480 (which provides food aid to needy foreign countries), and establishing long-term, grain buying agreements with other nations. Since the 1972 grain sale to the Soviets, which depleted U.S. inventories and contributed to a dramatic rise in prices, an elaborate export reporting system has been established. This system enables the Department of Agriculture to monitor grain exports and, when the market's stability may be threatened, to limit them.

Income Maintenance

Another major set of programs provides supplemental income payments to participating farmers when the supply and demand management programs alone cannot provide a profit-making market price for farm commodities. As farm costs continued to rise, the loan rate failed to guarantee farmers a break-even price for their production. Since increasing the loan rate would have increased the size and cost of Government inventories as well as farm revenues, a target price was established in 1973 to provide supplemental farm income payments. Participating farmers became eligible for a Government payment equivalent to the difference between the market price and the target price.

Management Programs Interlinked

These three sets of programs are closely interrelated and must operate simultaneously to be effective. Some critics argue, for example, that income maintenance programs keep some marginal producers in business and generate excess production. The additional output in turn creates a surplus that tends to reduce prices, creating the need to expand our export demand to reduce excess supplies and return prices to more reasonable levels. To effectively manage these complex interactions, policymakers need a broad "systems" view of agriculture.

A SYSTEMS APPROACH TO FARM POLICY ANALYSIS

A system is a collection of components that interact with each other to perform a function. A farm is a component that interacts with markets, distribution networks, consumers, the environment, labor, machinery, and the Federal Government to produce food and fiber in the system known as the agricultural economy.

Most scientific and economic training focuses on taking complicated systems apart before analyzing them, an extremely useful strategy in increasing the understanding of each component. Effective policies, however, must be based on analytical syntheses of major components' interactions. One cannot design farm policy to act on the commodity market without considering the impact on prices, demand for exports, farm incomes and investment decisions, barriers to entry, and annual production planning. A policy that attempts to reduce prices in the short run will shift future investment and production patterns, which results in much higher future prices to consumers. The long-term effect of a policy that focuses on only one component of the total system will likely be completely different from the desired policy goal or objective.

Thus, we must take an integrated systems approach to farm policy analysis to understand true cause and effect relationships and to understand trade offs between the short and the long term. To understand the farmer and his problems, one must also understand the commodity markets, distribution networks, consumer behavior, capital markets, and export trade in a global context. Current farm policies and market conditions are alteady influencing future farm investment planning and farm structure. The planning and structural changes, in turn, will influence market conditions farther into the future.

THE GRAIN1 MODEL

To study the interactions among components of the agricultural economy, computer programmers developed a computer simulation model of the U.S. wheat production system. The model, GRAIN1, uses the system dynamics method to simulate the behavior of complex systems. In system dynamics, information feedback and control concepts are extended to nonlinear social systems. The system dynamics computer language, DYNAMO, allows the user to represent real-world decision mechanisms as simple mathematical equations.

This method has been used to model such processes as inventory control and production planning in industrial organizations,[1] capital investment decisions giving rise to commodity production cycles,[2] and the policy and market forces that will govern the energy transition of the United States from oil and gas to alternate sources.[3]

Figure 1, the basic structure of the GRAIN1 model, illustrates some major relationships in the U.S. wheat production system. The arrows point from causes to effects; whether the arrowhead is open or closed indicates the nature of the influence. A closed arrowhead (plus) indicates that a change in the influential variable causes a change in the same direction of the influenced variable, when all other elements of the system are assumed to remain constant. An open arrowhead (minus) indicates that the influenced variable will move in the opposite direction.

Analysts developed the model's basic structure by examining the direct cause-effect relationships within the wheat sector, through interviews with wheat farmers, bankers, equipment dealers, Government policymakers, farmers, and co-op managers. The analysts combined the responses with conventional economic theory and historical statistics to obtain the major causal relationships between each of the major model sectors.

The wheat *production and market sector* examines the existing complement of land and equipment and the application of inputs. It calculates annual production, sets the season's average price, and determines the year's consumption, both domestic and export.

The *farm program sector* models the effect of Government programs on wheat farming. In addition to the supply and demand management and the income maintenance programs described earlier, this sector represents the effects of programs designed to conserve the land base from decay caused by erosion or by the extraction of key soil nutrients. It includes Federal Government expenditures on research and development directed at increasing the yield potential of American farmland. These programs are explicitly included under such headings as wheat allotments, parity payments, marketing certificates, disaster payments, deficiency payments, Commodity Credit Corporation reserve stocks, research and development, and conservation programs.

The *goal formulation sector* sets objectives for farmers during the coming year. In this sector, farmers are assumed to compare performance, as defined by annual income per farm, with performance of those not pursuing a career in farming. Based on this comparison, the sector formulates income and production goals for the coming year.

Once an output goal is established, the *factor allocation sector* calculates the investment necessary to meet it. On occasion, when the annual cash flow is insufficient to warrant new debt acquisitions, as determined in the finance sector (described below), the required level of investment will not be met. The factor allocation sector divides the annual investment between two strategic alternatives. Farmers can increase their output by expanding farm size and purchasing the additional capital equipment, or they can farm their existing land more intensively through increased use of current inputs.

The *farm population and land sector* measures the profitability and attractiveness of wheat farming. It determines the number of farmers who wish to enter

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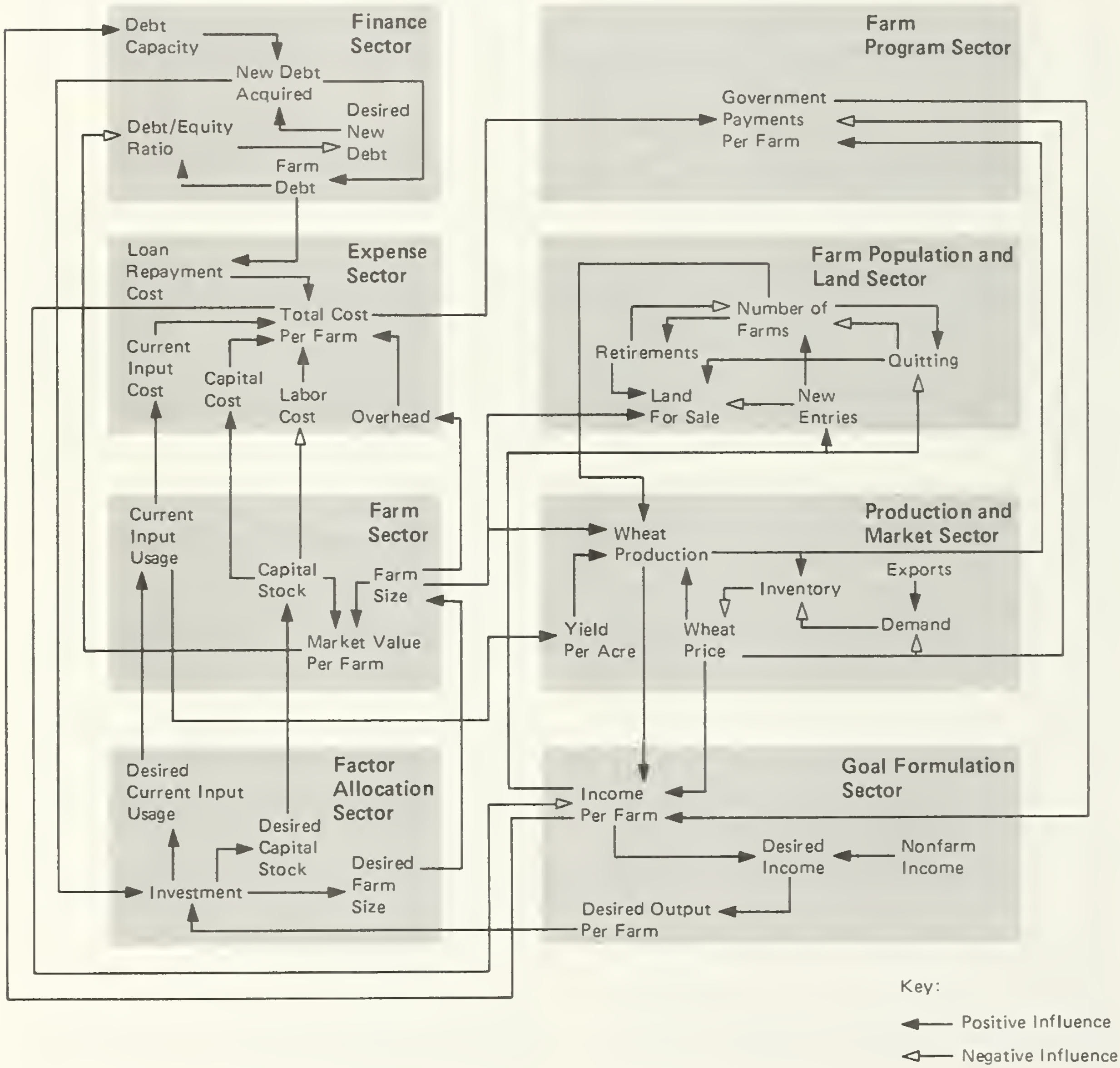
[1] Forrester, Jay W., *Industrial Dynamics*, The MIT Press, Cambridge, MA, 1961.

[2] Meadows, Dennis L., *Dynamics of Commodity Production Cycles*, Wright-Allen Press, Inc., Cambridge, MA, 1970.

[3] Naill, Roger F., *Managing the Energy Transition*, Ballinger Pub. Co., Cambridge, MA, 1977.

FIGURE 1
Major Causal Relationships in Wheat Production



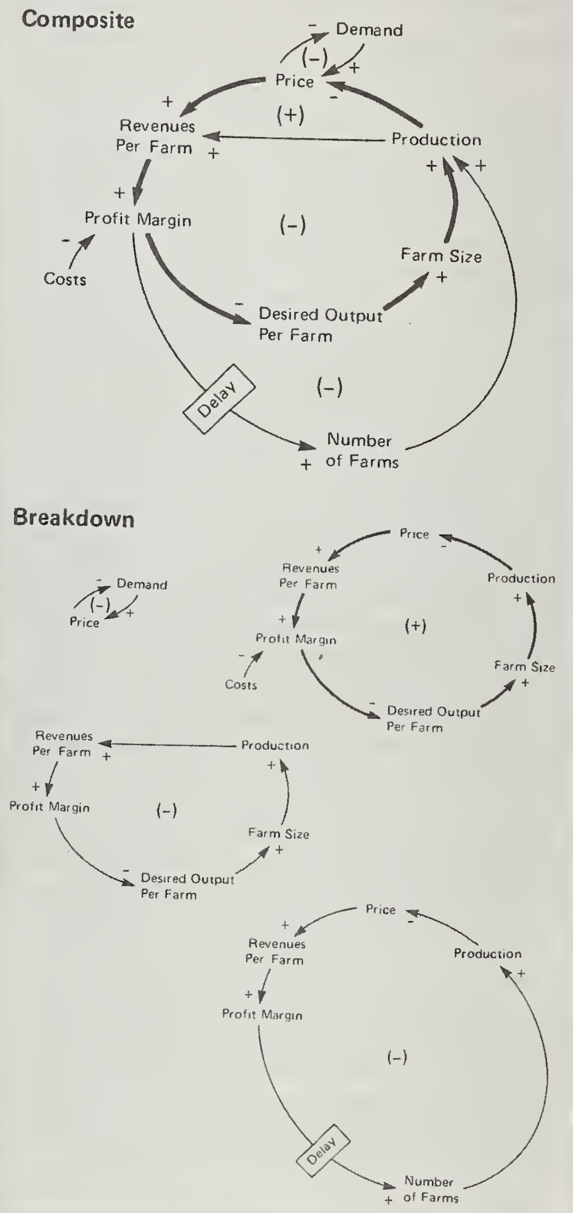
the industry and the number of established farmers who quit for economic reasons. This sector records the natural maturation process of established farmers, calculates the number of normal retirements that occur each year, and records transfers of property. The sector also measures the total demand for farmland, by both established and potential farmers, and apportions the available land between the two groups.

The *finance sector* measures wheat farmers' annual cash flow and determines the total amount of supportable debt. It also performs an accounting of annual debt acquisition and repayments, and records the total level of farm debt.

After the finance sector makes and approves the investment decision, farmers make the actual changes in factor inputs. They buy land, if available, which increases the average size of farms. They use differing amounts of current inputs each year and they buy new capital equipment and buildings. The *farm sector* accounts for new capital acquisitions, liquidations of existing stocks, and physical depreciation. As more investment occurs, the asset base increases, and farm market value increases.

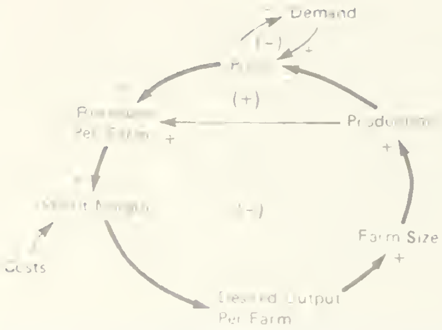
The *expense sector* calculates the total annual costs to subtract from total revenues to produce annual farm income. The major expenses calculated by GRAIN1 include annual loan repayments, current input costs, capital and labor expenses, property taxes, and other overhead expenses.

FIGURE 2
Feedback Structure of the GRAIN 1 Model



KEY MECHANISMS FOR STRUCTURAL CHANGE IN THE AGRICULTURAL ECONOMY

The basic structure of the GRAIN1 model can be simply represented by four feedback loops (figure 2). The essential model structure has one strong positive feedback loop, which drives the entire system, and three weaker negative feedback loops, which counteract the key positive loop. The positive feedback chain outlined in heavy black lines in figure 2 may, experimentation based on the model suggests, be a primary cause of structural change in American agriculture.



Farm costs have been rising steadily because of increasing capital and energy costs. The resulting diminished profit margins have caused farmers to seek ways of reducing costs. Historically, the drive for cost reduction has led to additional investment in technology and in mechanical equipment. In conjunction with capital investment, diminishing profit margins have also led, in many cases, to increases in desired output (to provide a broader base over which fixed costs could be spread). Farmers have expanded the size of their farms, making use of mechanized equipment. As long as the land base existed to draw from, the number of acres in production also rose, resulting in greater production and subsequent decreases in the market price and further reductions in the profit margin. This round of adjustments then set the stage for another round by those who could make the additional investment.

In a period when our agricultural land base has remained fixed, a second set of dynamics has been at work. When the supply of land is fixed, farmers could not increase farm size, unless other farmers whose operations were marginal went out of business and offered their land for sale. This process is shown by the large negative feedback loop in the lower part of figure 2. Because it may take several successive years of depressed profit margins to ultimately drive a farmer out of business, this negative feedback chain contains a delay that is important to the dynamics of the wheat production system. It causes the desire to increase farm size to be "out of phase" with the availability of farms for sale by operators who are going out of business.

In the manner described above, declining profit margins, the availability of new technologies, and farms available for purchase, prompted successive rounds of farm capital investment to increase farm size and output.

Note that as long as technological improvements make further investment feasible, the positive feedback chain would tend to drive the average farm size to increase indefinitely unless one of the negative feedback loops became strong enough to counteract it. A fixed agricultural land base represents one condition that counteracts the growth tendency of the positive feedback loop.

Policy Analysis

Analysts used the GRAIN1 model to test six forces and policies that act on the driving positive feedback loop which raises farm size.

Reference Run

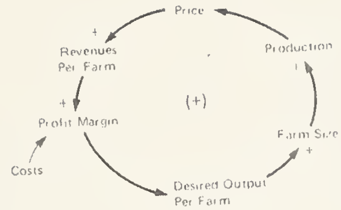
Figure 3 presents the results of the assumptions contained in the major feedback loops of the GRAIN1 model. The figure shows the behavior of the U.S. wheat production system from 1976 to 2000 that is likely to result if no changes are made in the existing system structure. Production and total domestic plus export demand are projected to rise to over 2.2 billion bushels annually.

The amount of exports increases to more than 1.4 billion bushels by 1990 and levels off through the end of the century. The carryover, or remaining inventory, rises to nearly 1 billion bushels by 1979 and becomes steadily lower, to about 140 million bushels by the year 2000. The wheat price drops from nearly $3.70 per bushel in 1976 to $2 through 1979; this drop is followed by price oscillations that exceed $6 in 1983 and $7 after 1988. During the period between 1976 and 2000, the average farm size continues to increase, from 962 acres to 1,262 acres per farm. At the same time, the number of farms would fall from 526,000 to 389,000.

If farm costs continue to rise and no structural changes occur, the 50-year trend toward fewer and larger farms can be expected to continue. The increased cost of production raises the price of wheat, and annual production begins to level off because the per-acre yield is assumed to be approaching its biological limit; thus, it will not increase as rapidly as in the past.

Alternate Futures

Policies that act on the positive feedback loop can make the future look different from that highlighted in the reference run. To illustrate this point and to understand better some of the public policy trade offs, analysts tested six alternate sets of assumptions using the GRAIN1 model.



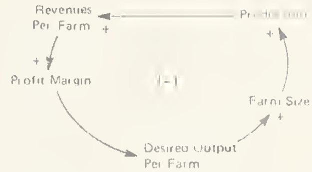
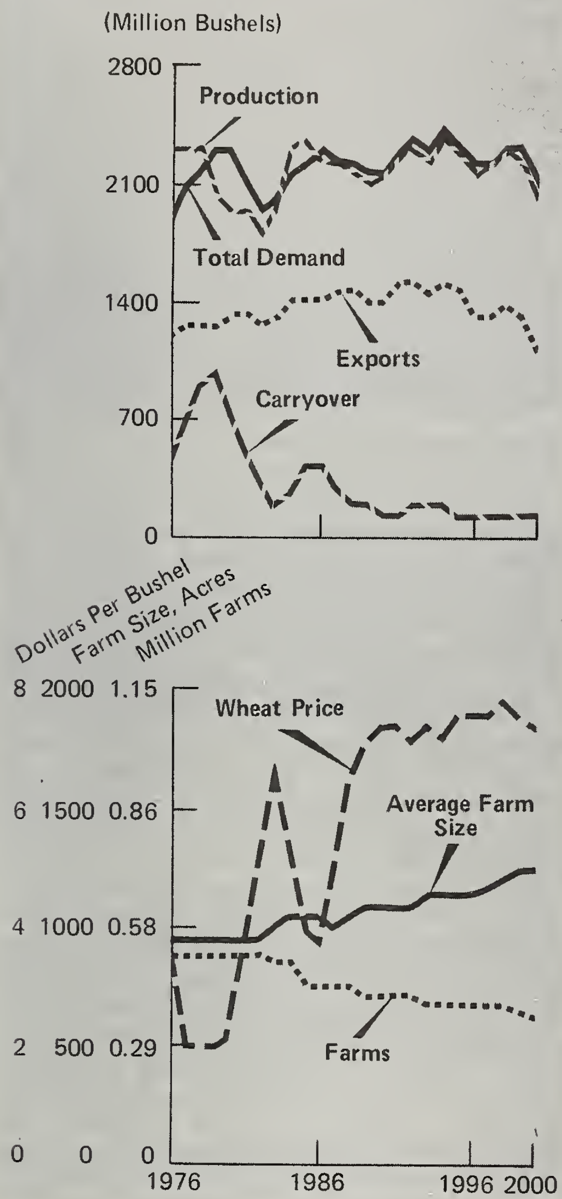


FIGURE 3
Reference Run, GRAIN 1 Model



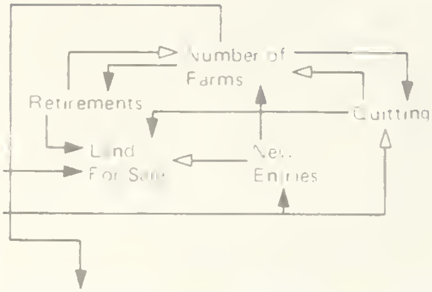
The table compares the six alternate futures and the reference run. The figure presents the year 2000 values for the number of wheat farms and the average farm size, along with the average annual Government cost, production, and exports.

In the first alternate future computer simulation, all supplemental disaster and deficiency payments from the Federal Government to farmers were suspended after 1976. In this case, 70,000 fewer wheat farmers are in business by the year 2000, operating farms with an average size of 1,462 acres. This change can be attributed to the fact that the suspension of farm program payments reduced total farm income, causing the farmers to go out of business. Production falls 180 million bushels annually, throughout 1976-2000. The lower level of production allows the wheat production sector to support fewer bushels of exports annually.

The second alternate future restricts farm size by law to a maximum of 1,000 acres. By the year 2000, 89,000 more farms than in the reference run are producing wheat. Market prices rise slightly above those in the reference run while Government costs fall $84 million. Production and exports also decline slightly. Although the policy is reasonably effective in halting the decline in farm numbers and in holding down Government costs, it would result in above-normal prices and would probably be unpopular among farmers wishing to expand the size of their farms.

The third alternative cuts the average level of exports 15 percent from 1976 to 2000. Such a policy keeps farm prices more stable by protecting grain inventories through mandatory export controls. In this case, grain inventories do not become depleted, farm prices remain lower than in the reference run, farm incomes decline, and more wheat farmers go out of business. By the year 2000, only 354,000 farmers would be in business, and the average farm size would increase to 1,382 acres. Lower prices increase Government payments dramatically to $738 million a year. Lower prices also stimulate less wheat production and, because of the mandatory Government export controls, less production is exported.

In the fourth run, weather is assumed to be more favorable to farming than in the reference run. In the GRAIN1 model, fluctuations are represented by a random weather multiplier that reduces production by an unpredictable amount. In the reference run, the weather



GRAIN 1 alternate futures, U.S. wheat farms

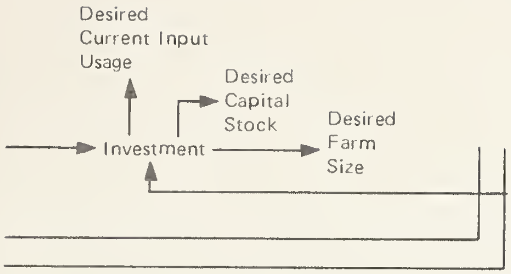
Policy title	Year 2000			Average annual changes	
	Number of farms	Average farm size	Government cost	Production	Exports
	Thous.	*Acres*	*Mil. dol.*	*Bil. bu.*	
0. Reference run	389	1,262	392	2.28	1.42
1. Suspended payments	319	1,462	---	2.10	1.17
2. Restricted farm size	478	1,000	306	2.24	1.38
3. Reduced exports	354	1,382	738	2.12	1.19
4. Favorable weather	310	1,520	629	2.36	1.43
5. Adverse weather	468	1,079	168	1.96	1.02
6. Talmadge proposal	441	1,020	511	2.29	1.42

multiplier has a mean value of 0.89 and a standard deviation of 0.04. This means that, on the average, only 89 percent of expected production is actually harvested. For the favorable weather assumption, the mean is set to equal 0.95 with a standard deviation of 0.0. In this alternate future, 5 instead of 11 percent of the crop is lost annually because of the vagaries of weather.

Somewhat paradoxically, more favorable weather conditions between now and the end of the century would not be favorable to farmers. Good weather would result in greater production (2.35 billion bushels) and lower prices. Consumers would reap the benefits of the lower prices, while the decrease in farm income would mean fewer farmers, larger farms, and higher Government costs. Because of higher production and lower prices, exports would also rise slightly.

The fifth alternate future presents consistently poor weather conditions, in which the mean weather multiplier is set at 0.8. This choice means that weather destroys 20 percent of the annual crop. Adverse weather results in lower production (1.96 billion bushels per year), higher prices paid by consumers, higher farm income, more farmers, and a lower average farm size. High prices also reduce the need for the Government's supplemental income payments while the lower production level lowers wheat exports.

The sixth simulated agricultural future models a proposal presented recently by Senator Herman Talmadge of Georgia. Some farmers state that the target price USDA pays to participating farmers in times of low prices continually lags far behind the actual cost of producing wheat. Moreover, the Congress sets the target price with each farm bill and, in a case of rapidly rising costs, this price is inadequate. Talmadge proposed that the target price be calculated based on the cost of production and be set to equal 75 percent of that cost. Thus, the target price should rise steadily and be matched to the cost of production. This policy also appears reasonably effective in curtailing the trend toward fewer and larger farms, but at a somewhat higher cost in Government payments, approximately $119 million more than in the reference run. These payments make it possible for 52,000 more farmers, than in the reference run, to be in business by the year 2000. Similarly, farm size averages below that in the reference run, production is slightly above normal levels, while exports remain at the reference run value. The extra production also results in lower prices for consumers.



CONCLUSIONS

Of the six alternate futures depicted in the table, only four—suspended payments, restricted farm size, reduced exports, and the Talmadge proposal—can be somewhat controlled by policymakers, given current technology. Two of these, suspended payments and reduced exports—tend to reduce production and exacerbate the trend to fewer and larger agricultural production units. The complete suspension of farm payments seems least desirable because it results in the largest reduction in both farm numbers and production compared with the reference run. Reduced exports cause a similar decline in production and farm numbers at a dramatically increased cost to the Government. At the same time, the Government and the farmers lose the export revenues resulting from the mandatory export controls.

The other two futures—restricted farm size and the Talmadge proposal—help maintain the number of smaller family farms. Of these two futures, restricting farm investment seems to be the least desirable because it also restricts production, and it causes higher prices for consumers (although the Government's cost is slightly reduced). The Talmadge proposal would cost about $119 million per year more than the reference run and would increase production while lowering prices and allowing 441,000 farmers to stay in business.

In any of the six futures, it will take roughly the same amount of total revenue consisting of farm income and Government transfer payments to keep a farmer in business. As agricultural programs are currently structured, policymakers can decide only where the money will come from. If farm prices are low, consumers may pay less for agricultural commodities, but they must pay more in Federal taxation to provide the necessary income supplements. Or they must forego enough Government spending on other national priorities to make up the difference. Policies that result in lower Government costs are likely to reduce production and increase the prices paid by consumers for agricultural commodities.

A balance between high consumer prices and high Government costs appears difficult to maintain. Government policymakers need a more systematic way to project the consequences of their policy decisions, not only over the short term, but over the long term as well. Policies that seek to increase farm incomes in the short run, for example, may contribute to overinvestment and thus cause further distress in the future.

A model such as GRAIN1 can be useful for testing policies before they are implemented, which can permit a better assessment of the short- and long-term trade offs and the consequences. The model cannot replace human decisionmaking, but it can enhance it. GRAIN1 can help decisionmakers identify ways to influence the future rather than simply react to the present.

In Earlier Issues

Granted that Keynes was the most influential economist of his generation, the question that other economists and wide-awake laymen have pondered is, Why? . . . Keynes' influence came from an amazing amalgamation of heredity, intellectual environments, a keen and exploring mind of a scintillating quality, remarkable diversity of interests and contacts, amazing versatility, a liking for concentrated and sustained work, courage and daring, and endless resource and ideas.

Caroline Sherman (Review of: *The Life of John Maynard Keynes* by R. F. Harrod)
July 1951, Vol. 3, No. 3, pp. 106-7

An Empirical Comparison of Functional Forms for Engel Relationships

By Larry Salathe*

The functional form used to represent expenditures or consumption as a function of income and household size (Engel relationship) dramatically affects estimates of elasticities of these variables. This impact also holds true when the elasticities are computed at the mean of the sample used. When per capita expenditures were expressed as a function of per capita income, the double-and semi-log functional forms provided the best statistical fit. When expenditures were expressed as a function of household size and income, the quadratic functional form provided the best statistical fit.

Keywords:

Engel curves
functional form
goodness of fit
income
household size

INTRODUCTION

A variety of functional forms have been suggested to represent Engel relationships.[1] The most widely used include the linear, quadratic, double logarithmic, semi-logarithmic, inverse, and logarithmic-inverse. Because each functional form possesses some desirable characteristics, no single form has found general acceptance among economists (*2*, *8*, *5*, *9*, *6*).[2]

Few researchers have examined the discrepancies in results obtained by assuming different functional forms for Engel relationships or the ability of these different functional forms to "fit" the same data. Previous research indicates that the choice of functional form can substantially influence the (estimated) income elasticity. Income (expenditure) elasticity for a particular product can vary by 50 percent or more at the means because of differences in the functional form (*9*).

Prais and Houthakker compared the fit of the linear, double logarithmic, semi-logarithmic, inverse, and logarithmic-inverse functional forms using grouped data. They measured goodness of fit by the correlation between actual and predicted values of the dependent variable.

The interpretation of this measure of goodness of fit varies, depending on whether the dependent variable is transformed before estimation. For example, for the double logarithmic functional form, the computed correlation coefficient measures the correlation between the natural logarithm of observed expenditure (quantity) and the predicted value for the natural logarithm of expenditure (quantity).

However, for the linear functional form, the correlation coefficient measures the correlation between observed expenditure (quantity) and predicted expenditure (quantity). Thus, a more consistent measure of goodness of fit would be to transform the predicted values for the double logarithmic functional form to natural numbers before computing the correlation coefficient.

The quadratic functional form has attracted only limited attention from economists (*7*). This disinterest is somewhat puzzling because the form allows the marginal propensity to consume (spend) and the income elasticity to vary with the level of income. Such flexibility is particularly useful for analyzing expenditures or consumption of commodities considered to be necessities.

OBJECTIVES

The objectives of this article are (1) to examine differences in estimated household size and income elasticities generated by different functional forms including quadratic and (2) to compare the ability of different functional forms to fit ungrouped data. Results should provide a better understanding of the relationship between functional form and estimated income and household size elasticities. In addition, since one criterion for selecting functional forms is goodness of fit, the study should indicate which forms are most appropriate for estimating Engel relationships.

RESULTS

The data used in the analysis consist of 7,143 households in the spring portion of the 1965 USDA Household Food Consumption Survey. The data on food expenditures were grouped into seven expenditure groups: dairy products (excluding butter), fats and oils, flour and cereals, beef and pork, vegetables, fruits, and total food consumed at home.

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[1] An Engel relationship can be defined as describing how expenditures or consumption of a particular commodity varies with household income and size.

[2] Italicized numbers in parentheses refer to items in References at the end of this article.

The functional form used to represent expenditures as a function of income and household size (Engel relationship) dramatically affects estimates of elasticities of these variables. This impact also holds true when the elasticities are computed at the mean of the sample used. When per capita expenditures were expressed as a function of per capita income, the double- and semi-log functional forms provided the best statistical fit. When they were expressed as a function of household size and income, the quadratic functional form provided the best statistical fit.

Per Capita Specification

The first set of results was generated by specifying six different functional relationships between per capita and income. Table 1 contains the mathematical form of the six functional forms and summarizes the properties of each. According to economic theory, the functional form used in estimating Engel relationships should satisfy the adding up constraint. This property implies that predicted expenditures for each good add up to total expenditures. This is the only property which economic theory gives us. Economists have also suggested that the demand for certain goods, in particular, food, may reach a satiety level as income increases.

One disadvantage of the double-logarithmic and logarithmic-inverse functional forms is that observations having zero expenditure cannot be used in the analysis. Eliminating these observations will result in an inflated estimate for the income (expenditure) elasticity. One could assign a small number to the dependent variable when its recorded value equals zero. Here, a value of one cent was assigned as the level of expenditure when the household recorded no expenditure for a particular food group. Thus, the parameters in all the functional forms were estimated from the same data set.

Even though all expenditure-income elasticities were computed at the sample means, substantial differences still exist in the elasticities (table 2). The inverse and log-inverse functional forms generated expenditure-income elasticities considerably lower than those from the other four functional forms. Of those four forms, the double logarithmic produced the highest expenditure-income elasticity for dairy products, beef and pork, vegetables, fruits, and total food; and the lowest income elasticity for flour and cereals, and the fats and oils food groups. Compared with the linear functional form, the quadratic form provided expenditure-income elasticities having a higher absolute value for all food groups except vegetables, which was the only expenditure category in which both per capita income and per capita income squared were positive and significant.

To compare the ability of each functional form to fit the data, correlation coefficients and mean squared error

Table 1—Properties of alternative functional forms for Engel relationships, expenditures, and income expressed in per capita terms

	Functional form	Marginal propensity to spend	Expenditure-income elasticity	Adding-up constraint	Saturation level	Zero observations
Linear	$E=a+bY$	b	bY/E	holds	no	can be used
Quadratic	$E=a+bY+cY^2$	$b+2Y$	$\frac{(b+2cY)Y}{E}$	holds	no	can be used
Double-logarithmic	$1nE=a+b1nY$	bE/Y	b	does not hold	no	cannot be used
Semi-logarithmic	$E=a+b1nY$	b/Y	b/E	does not hold	no	can be used
Logarithmic-inverse	$1nE=a+b/Y$	$-bE/Y^2$	$-b/Y$	does not hold	yes	cannot be used
Inverse	$E=a+b/Y$	$-b/Y^2$	$-b/EY$	holds	yes	can be used

E is per capita expenditures, and Y is per capita income.

Source: (*6*, p. 50).

Table 2—Estimated expenditure-income elasticities from alternative specifications of Engel relationship *

Expenditure item	Functional form					
	Linear	Quadratic	Double log	Semi-log	Inverse	Log-inverse
Dairy products	.128	.150	.217	153	.049	.083
Fats and oils	.168	.177	.151	163	.042	.045
Flour and cereals	−.095	−.112	−.225	−.111	−.032	−.054
Beef and pork	.299	.319	.361	.300	.078	.118
Vegetables	.283	.269	.322	.250	.059	096
Fruits	.293	.325	.519	.295	.078	.178
Total, food[1]	.212	.229	.236	.217	.059	.075

*Calculated at sample means.

[1] Includes only food consumed at home.

Table 3—Mean squared error statistics for various functional forms

Expenditure item	Linear	Quadratic	Double log	Semi-log	Inverse	Log-inverse
	Dollars/week					
Dairy products	5.416	5.257	4.958L	4.997	5.738H	5.121
Fats and oils	.545	.542	.529L	.536	.588H	.540
Flour and cereal	.634	.633	.738	.632L	.652	1.043H
Beef and pork	26.321	25.817	25.314L	25.341	33.404H	27 290
Vegetables	3.673	3.722	3.447L	3.693	4.554H	3.694
Fruits	2.844	2.773	2.907	2.754L	3.408H	2.997
Total, food	167.973	161.922	139.517L	153.044	219.228H	167.123

H—highest value for each expenditure group.
L—lowest value for each expenditure group.

statistics were computed. In every case, the correlation coefficients measure the correlation between observed and predicted expenditures in natural numbers. To provide greater detail on each functional form's ability to fit the data, mean squared error statistics were also computed by converting observed and predicted expenditure values to natural numbers.

Only the mean error statistics appear (table 3) because the two sets of statistics gave the same results. Generally, the double- and semi-log functional forms have the lowest mean squared error while the inverse functional form had the highest mean squared error. However, for the flour and cereals group, the linear, quadratic, semi-log, and inverse functional forms fit the data better than the double log. Since the estimated expenditure-income elasticity for the flour and cereals subgroup was negative, the double logarithmic functional form appears to be a poor choice when estimating Engel relationships for commodities with negative income elasticities.

The double-logarithmic and semi-logarithmic functional forms may be appropriate when per capita expenditures are expressed as a function of per capita income. However, they may not be the most appropriate when income and household size are treated as separate independent regressors.

Household Size and Income as Separate Regressors

In some recent studies, researchers have specified household expenditures as a function of income and household size rather than expressing expenditures and income in per capita terms (*6*, *3*). The double logarithmic and semi-logarithmic functional forms may be appropriate when per capita expenditures are expressed as a function of per capita income. However, they may not be the most appropriate when income and household size are treated as separate independent regressors.

When expenditures and income are expressed in per capita terms, multiplying income and household size by the same constant does not alter per capita expenditures. This implies that when per capita expenditures are expressed as a function of per capita income, the estimated income and household size elasticities are restricted to sum to one. This restriction is relaxed when income and household size are used as separate regressors.

The estimated household size and income elasticities for 15 alternative functional forms appear in table 4. The relations expressing expenditures as a function of the inverse of income provided the lowest expenditure-income elasticities. The relations expressing the natural logarithm of expenditures as a function of the natural logarithm of income usually produced the highest expenditure-income elasticities. The household size elasticities also exhibited the same patterns, but their relative differences are considerably smaller. After excluding the functional forms expressing expenditures as a function of the inverse of income, the estimated expenditure-income elasticities continued to vary, by as

Table 4—Estimated expenditure-income and household size elasticities for functional forms, income and household size as separate regressors*

Functional form	Expenditure-income elasticities: Dairy products	Fats and oils	Flour and cereals	Beef and pork	Vegetables	Fruits	All food[1]	Household size elasticities: Dairy products	Fats and oils	Flour and cereals	Beef and pork	Vegetables	Fruits	All food[1]
(1) $E=a+bY+cY^2+dS+fS^2$	.139	.106	−.142	.290	.199	.292	.195	.592	.593	1.086	.452	.425	.378	.535
(2) $E=a+bY+cY^2+d/S$	.125	.075	−.210	.270	.179	.274	.173	.504	.488	.802	.401	.381	.319	.449
(3) $E=a+bY+cY^2+d\ln S$	.134	.084	−.213	.281	.190	.280	.181	.599	.525	1.021	.462	.436	.378	.534
(4) $\ln E=a+b\ln Y+c\ln S$	.210	.135	−.178	.367	.292	.489	.196	.762	.799	1.370	.657	.585	.389	.643
(5) $\ln E=a+b\ln Y+cS+dS^2$	.212	.150	−.150	.376	.298	.488	.206	.701	.731	1.307	.591	.520	.347	.598
(6) $\ln E=a+b\ln Y+c/S$	.176	.093	−.228	.330	.257	.468	.168	.710	.766	1.237	.640	.577	.374	.597
(7) $E=a+b\ln Y+cS+dS^2$	.109	.088	−.113	.232	.152	.226	.155	.591	.575	1.084	.447	.421	.377	.535
(8) $E=a+b\ln Y+c\ln S$	.102	.065	−.182	.222	.142	.214	.139	.598	.570	1.022	.455	.429	.376	.531
(9) $E=a+b\ln Y+c/S$	.091	.053	−.186	.211	.131	.207	.130	.504	.483	.806	.391	.372	.315	.445
(10) $\ln E=a+b/Y+c\ln S$	.097	.058	−.063	.164	.128	.202	.082	.794	.822	1.330	.717	.634	.480	.678
(11) $\ln E=a+b/Y+cS+dS^2$	.098	.066	−.048	.167	.131	.200	.087	.726	.751	1.278	.639	.560	.418	.627
(12) $\ln E=a+b/Y+c/S$	.077	.035	−.089	.142	.108	.187	.066	.741	.787	1.190	.698	.624	.468	.632
(13) $E=a+b/Y+c/S$	.026	.013	−.076	.067	.036	.065	.038	.530	.500	.770	.447	.412	.370	.481
(14) $E=a+b/Y+c\ln S$	.034	.021	−.072	.076	.044	.072	.046	.622	.587	.986	.507	.466	.427	.565
(15) $E=a+b/Y+cS+dS^2$	.038	.032	−.038	.080	.049	.077	.053	.610	.590	1.064	.488	.450	.417	.560

*Calculated at sample means. E is expenditure, Y is income, and S is household size.

[1] Includes only food consumed at home.

much as 100 percent. For all functional forms, the estimated household size elasticities varied by about 50 percent.

Comparing the estimated expenditure-income elasticities for the per capita models with the functional forms having income and household size as separate regressors (tables 2 and 4) provided additional insights. The expenditure-income elasticities obtained for the quadratic, double-log, semi-log, inverse, and log-inverse forms when expenditures and income were expressed in per capita terms usually exceeded the elasticities for these same functional forms when household size and income were treated as separate regressors. In addition, the sum of the expenditure-income and household size elasticities usually fell far below one.

Tables 5 and 6 present the rankings by functional form for the mean square error (lowest to highest) and correlation coefficients (highest to lowest), respectively. By both criteria, functional form (1)—expenditures as a function of income, income squared, household size, and household size squared—performed the best (produced the lowest mean squared error and highest

Table 5—Rankings of mean squared error statistics, 15 Engel functional forms

Expenditure item	Functional form*														
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dairy products	1	7	3	10	8	13	2	4	9	14	12	15	11	6	5
Fats and oils	1	7	2	10	13	12	3	4	8	11	15	14	9	6	5
Flour and cereals	1	11	4	7	9	14	2	5	12	8	10	15	13	6	3
Beef and pork	2	5	1	10	12	9	4	3	6	14	15	13	11	7	8
Vegetables	2	5	1	11	12	10	4	3	6	14	15	13	9	7	8
Fruits	1	5	2	10	11	12	3	4	6	13	14	15	9	7	8
Total, food	1	11	2	5	6	7	3	4	14	10	12	13	15	9	8

*Numbers correspond to the equations in table 4.

Table 6—Rankings of correlation coefficients, 15 Engel functional forms

Expenditure item	Functional form*														
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dairy products	2	13	5	6	1	4	3	7	14	12	9	10	15	11	8
Fats and oils	1	13	2	5	11	8	3	4	14	9	12	10	15	7	6
Flour and cereals	1	13	8	4	6	10	2	9	14	5	7	12	15	11	3
Beef and pork	3	8	2	4	7	1	6	5	9	12	13	10	15	11	14
Vegetables	2	7	1	6	8	3	5	4	9	13	14	10	15	11	12
Fruits	1	8	2	3	4	7	5	6	9	10	12	11	15	13	14
Total, food	2	13	3	1	5	6	4	7	14	11	12	9	15	10	8

*Numbers correspond to the equations in table 4.

Engel relationships which express expenditures and income in per capita terms may be too restrictive, as they force the sum of the income and household size elasticities to equal one.

correlation coefficient). Functional form (3)—expenditures as a function of income, income squared, and the natural logarithm of household size—also provided an above average fit to the data. Both of these functional forms produced only moderately different expenditure-income and household size elasticities at the sample means. The mean squared error statistics were above average for the linear logarithmic functional form for all food groups except total food, and flour and cereals (functional form 4, table 5).

CONCLUSIONS

The choice of the functional form dramatically affects estimated income and household size elasticities. Income elasticities derived from the inverse and log-inverse functional forms should be interpreted with caution, as, in this study, these forms provided very low income elasticities and poor statistical fits to the data. The double log usually provided the best statistical fit and also the highest income elasticity for models expressing per capita expenditure as a function of per capita income. The double-log fit poorly the flour and cereals expenditure data, which suggests that it is a poor choice when estimating Engel relationships for inferior commodities. The semi-log and quadratic functional forms provided better statistical fits to the data than the linear, inverse, or log-inverse functional forms.

When expenditures were expressed as a function of household size and income, the quadratic form having income, income squared, household size, and household size squared as explanatory variables provided the best statistical fit. For the 15 functional forms analyzed, the linear logarithmic functional form's fit to the data was about average. Thus, the double-logarithmic functional form seems appropriate when per capita expenditures are expressed as a function of per capita income. The linear logarithmic seems, however, to be a poor choice when income and household size are used as separate regressors in the Engel function. The estimated income and household size elasticities generated from the different models in which income and household size are treated as separate regressors suggest that the sum of these elasticities is usually different from one. Thus, Engel relationships which express expenditures and income in per capita terms may be too restrictive, as they force the sum of the income and household size elasticities to equal one.

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Structural Differentiation and Rural Development

By Richard G. Stuby*

This article enlarges on the concept of structural differentiation as defined below, and it presents the results of one attempt to measure the concept as it relates to the issues of rural development.

Modern, industrialized, or "developed" societies are characterized by a profusion of highly specialized functional units, extreme division of labor, and rationality of production. Less developed or "underdeveloped" societies are characterized by a lack of these. Similarly, within any given society, and regardless of the form of political economy, we note varying levels of agglomeration, specialization, and division of labor among the society's functional units. At one pole of this variation we observe developed, urbanized areas with many highly specialized firms, organizations, governments or service structures. At the other pole we find the less developed rural hinterland with only a few firms, organizations, governments or service structures, each of which has more generalized functions.

Urbanized areas thus not only differ from rural areas in the sense of a larger, more concentrated population, but they also differ in that the socioeconomic structure of firms, organizations, governments, and institutions which support that population is more differentiated. One possible way of defining the level of development for an area, then, is to

Structural differentiation, a concept used here to measure differences between rural U.S. counties, can assist policymakers in determining degrees of rural development. The Guttman scale of structural differentiation, derived from Dun and Bradstreet retail establishment data, is examined for its validity as a measure and its ability to discriminate among counties. Valid, stable scales of differentiation can be built from secondary data sources and may help in research. They must be further refined in terms of their relationship with population size and density, economic growth, and individual quality of life.

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measure its degree of structural differentiation. The higher the degree of structural differentiation, the higher will be the level of development. This is not to say that structural differentiation is development, rather, that it may be a useful empirical referent for the historically elusive concept of development. If structural differentiation can be empirically measured or indexed, we may be more able to consider development at the conceptual level.

THE ROOTS OF STRUCTURAL DIFFERENTIATION

The concept of structural differentiation as it relates to rural development has its roots in the writings of Durkheim, Tonnies, Redfield, Becker, and Sorokin (see *19* and *20*).[1] The polarities in these writings–mechanical-organic solidarity; *gemeinschaft-gesellschaft*; folk-urban; sacred-secular, familistic-contractual —all describe, in some sense, undifferentiated versus differentiated society.

The organic, urban, secular, contractual, *gesellschaft* society is characterized by a profusion of units, each with specialized functions, extreme division of labor, and rationality of production that describe modern, industrial, developed societies. The other poles—organic, folk, sacred, familistic, *gemeinschaft*—are associated with rural, agrarian, preindustrial, or underdeveloped societies.

Despite the fact that these polarities inherently refer to a set of underlying continuums, researchers have often focused on the poles rather than the entire range of the continuum. As recently summarized by Warner:

> . . . in societies that are industrial, it can be misleading to speak of rural society and urban society as alternative social entities that can be compared with each other. That implies reification of separate social systems, which appears to be less and less tenable as the future unfolds (*25*, p. 307).

If the holistic view of society is accepted, variables must be developed to express differences along meaningful and quantifiable dimensions of that society. Yet it is here that the rural-urban continuum and

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[1] Italicized numbers in parentheses refer to items in References at the end of this article.

Structural differentiation, a concept used here to measure differences between rural U.S. counties, can assist policymakers in determining degrees of rural development. The Guttman scale of structural differentiation, derived from Dun and Bradstreet retail establishment data, is examined for its validity as a measure and its ability to discriminate among counties. Valid, stable scales of differentiation can be built from secondary data sources and may help in research. They must be further refined in terms of their relationship with population size and density, economic growth, and individual quality of life.

the other descriptive polarities fall short. The rural-urban continuum has been called "real but relatively unimportant" (*5*). Moreover, whatever reality it may have has been shown to be a multidimensional concept that resists measurement (*1*).

Structural differentiation represents an alternative theoretical construct with enough solidity to be used as a variable in development issues relating to the rural-urban continuum. It is a concept which cross cuts academic disciplines as well as historically important theoretical constructs. It is a structural variable, applicable to all social systems regardless of differences in size, location, or time period. As it can function as a time series variable, it can focus on the dynamic processes of growth and specialization of functions within communities or regions. Thus, here, it is viewed as a generalized concept relating to urbanization, modernization, industrialization, or "development," whether the latter be labeled "community development," "economic development," or "rural development."

Structural differentiation may be an important variable in heuristic models of the development process as well as an objective indicator of the level of development itself. While these two aspects of differentiation are not easily separated, the focus of this article will remain on the latter; that is, using a scale of structural differentiation as an indicator of development.

GUTTMAN SCALING OF COMMERCIAL DIFFERENTIATION

Previous studies by Eberts (*7-9*), Sismondo (*23*), and others (*3*, *4*, *10*, *18*, *22*, and *26*) explored structural differentiation on a regional and county basis. They used Guttman scales to indicate the hierarchical differentiation of commercial services, medical specialties, and other institutional dimensions which relate to development. Other researchers (*12*, *14*, *15*, and *17*), working from the viewpoint of central place theory, have used a differentiation index, based on the frequency of commercial establishments, to index the hierarchy of places.

While both approaches contribute to the present work Guttman scale techniques will be used here to develop differentiation indexes. A Guttman scale invokes the idea of a hierarchy within the system as, by Guttman scale criteria, an observation exhibiting any given characteristic also exhibits all of the more basic or lower order characteristics (*11*). Thus, one can conceive of communities, counties, or places as ranging up and down a hierarchy of differentiation, from those with complex structures supporting unique, specialized, higher order functions to those having more simple, diffuse structures supporting only the more common, generalized, lower order functions. Structural differentiation is cumulative. It builds higher order structures on more generalized lower order ones in a sequence that is called "developmental." Thus, a Guttman scale is conceptually appropriate here.

Data

Data were compiled from the 1969 Dun and Bradstreet DMI file (*6*). This file contained records on approximately 2.7 million commercial establishments in the United States, coded by commercial function according to the Standard Industrial Classification (SIC) codes (*2*). The individual firm records were aggregated by FIPS county codes to provide data matrix containing frequencies for each of 1,051 SIC codes for each of 3,072 county units (*24*).[2] The SIC categories became the variables and the county units, the observations for data processing purposes.

[2] The list of 1,051 SIC codes on the tapes included some erroneous codes, which did not correspond to anything in the SIC manual. They probably resulted from keypunch errors when the file was constructed as they generally occur only once. Due to cost, no attempt was made to clean out these errors. Rather, they were simply noted in the original work tape compilation and not inputted into subsequent analyses.

The 3,072 county units generally correspond to those listed in FIPS PUB 6-2 (U.S. Dept. of Commerce, 1973) with the following exceptions: (1) Independent cities were merged with the county (or former county) in which they were located; (2) the entire State of Alaska was deleted from the file due to very sketchy reporting by Dun and Bradstreet for Alaskan Boroughs and Divisions; (3) Loving, Texas had no entries in the D&B file.

Does the Guttman scale indicate differentiation well and does it explain variance in independent variables included under the rubric of "development?"

Scale Construction

The initial thrust was to construct separate Guttman scales within each of the wholesale, retail, and service SIC major groups. This involved selecting the "best fitting" set of 12 items (SIC codes) within each group according to Guttman criteria.[3] Two additional scales were then constructed. One combined the best fitting set of 12 items from the retail and wholesale scales. The other, included items from retail, wholesale, and service groups.

Guttman scales with similar coefficients were obtained for the retail, wholesale, and service groups. Coefficients of reproducibility were 0.88, 0.88, and 0.89, respectively. Percentages of improvement were 0.16, 0.14, and 0.12, resulting in respective coefficients of scalability of 0.56, 0.53, and 0.53.[4] The combined scales had slightly better coefficients with reproducibilities of 0.89 and 0.90, improvements of 0.17 and 0.15, and scalabilities of 0.61 and 0.60. However, differences were not great; thus, the retail scale was selected for further analysis to preserve conceptual simplicity (table 1).

[3] The limitation of 12 items per scale is dictated by the design of the SPSS computer software package.
[4] See (*13*) for discussion of Guttman coefficients.

Evaluation of Scales

Does the Guttman scale indicate differentiation well and does it explain variance in dependent variables included under the rubric of "development?" At stake here are questions of both internal and external validity.

Internal Validity

Criteria of internal validity are expressed formally by the coefficients of reproducibility (REP), minimum marginal reproducibility (MMR), percentage of improvement (IMP), and coefficient of scalability (CS) (*11*, *13*). Although the coefficients in table 1 are not quite within the conventionally accepted levels of REP > 0.90, IMP > 0.20, and CS > 0.65, they are close enough to warrant further consideration and attempts at refinement. As

Table 1—Guttman scale for retail group for 3,072 U.S. counties, 1969

Scale score	SIC code	Scale item	Item distribution (percentage with)	Score distribution	
				N	Percent
12	5671	Custom tailor	14	160	5.2
11	5321	Mail order house	15	103	3.4
10	5993	Cigar store	15	121	3.9
9	5719	Miscellaneous home furnishings	24	182	5.9
8	5714	Drapery-upholstery	23	204	6.6
7	5996	Photo store	35	261	8.5
6	5311	Department store	44	296	9.6
5	5943	Stationery store	54	293	9.5
4	5462	Retail bakery	56	339	11.0
3	5231	Paint store	64	340	11.1
2	5611	Mens wear	75	338	11.0
1	5722	Appliance store	92	304	9.9
0	—	None of the above	—	131	4.3

Coefficient of reproducibility = 0.88.
Minimum marginal reproducibility = 0.72.
Improvement = 0.16.
Coefficient of scalability = 0.56.

these coefficients can be affected by the selection of items used, the process of item selection will be discussed briefly.

The process of constructing an acceptable Guttman scale of retail differentiation depended on finding that particular permutation of items which had the best Guttman fit from the universe of 68 SIC codes under the heading, retail. Several guidelines were used. First the SIC codes were crudely ordered based on general knowledge of the structure and distribution of retail establishments. For example, retail specialties, such as furriers, obviously were expected to appear only in counties containing a major city. If a retail service structure has the complexity and specialization to support a furrier, it probably also includes most other retail establishments. At the other extreme, the presence of gas stations and grocery stores would not discriminate among county units across the United States as each county would be expected to have both of these within its bounds. Within these extremes, some crude ordering estimates were made.

An item-by-item consideration also served to screen items for their applicability to all U.S. counties. Retail establishments that could not reasonably be assumed to exist in all counties were eliminated from consideration. Liquor stores provide a case in point. Because State laws controlling the retail distribution of liquor vary greatly, the position of liquor retail functions in the total retail structure is not consistent across all U.S. counties. In States with private sector, competitive-distribution outlets, a liquor store might be a low-order differentiation item. However, in States with State-operated or other tightly controlled distribution, it would be a higher order item occurring in fewer and larger places.

Second, previous research has shown relatively consistent orderings among several retail functions, particularly those common to fairly rural counties. Thus, some possibilities exist for ordering and selecting items for the rural end of the scale (*7-10*). However, the regional or local character of this research resulted in a range of items that would not adequately discriminate across both metro and nonmetro counties for the United States as a whole.

A third, and perhaps most useful approach, to the selection of scalable Guttman items from among the SIC codes involved the use of Yule's Q coefficients expressing bivariate, one-way association in a fourfold table (*21*, p. 249). Both Q and Guttman scales are based on the one-way association between variables.

In a perfect Guttman scale, perfect one-way association exists between all pairs of items. Thus, the values in an inter-item matrix of Yule's Q coefficients from a perfect Guttman scale would all be unity. It follows that a matrix of Q coefficients may be used as a guide to evaluate the potential for Guttman items. The values of Q range from -1.0 to $+1.0$; a value of $+1.0$ indicates a perfect one-way association and a value of -1.0 indicates a perfectly inverse association.

Thus, items with negative Q's were automatically eliminated from consideration. Then, items showing low inter-item Q's were evaluated and the most offending were dropped until a pool of suitable items remained for Guttman scale evaluation.

Thus, the item selection procedure basically involved a fitting process to find that permutation of items which empirically yielded the highest internal validity, without sacrificing discriminability.

Number of Items Used

The number of items included in a scale may also affect both internal validity and discriminability factors. A trade off exists between the number of items used and the internal validity coefficients because errors can be reduced by progressively weeding out the worst-fitting items. However, as the number of items is reduced, say to five or six, the technique may not be sensitive to important variations in the underlying continuum. Such a scale may not be much more useful than a set of subjective, nominal categories. Thus, extreme attempts to purify a scale may reduce its usefulness.

Reducing the number can also inflate the internal validity coefficients. If 12 items are spaced along a continuum, more overlap will occur in their endorsement-nonendorsement distributions, than if, say, six items were spaced along the same continuum. Fewer and more discrete cut points tend to submerge scale errors in the larger aggregate, which reduces the overall percentage of error and produces spuriously high coefficients.

As an illustration, examine the retail scale shown in table 1. The original 12 items were partitioned arbitrarily by assigning the even-numbered items to one six-item scale and the odd-numbered items to another. Thus, three sets of items range along the same continuum and the Guttman coefficients for them can be directly compared (table 2).

Both of the six-item scales partitioned from the original 12-item scale show better internal validity coefficients, particularly in improvement and scalability. Yet both of the shorter versions use items common to the larger. Ultimately, one must simply decide which aspect of the scale, discrimination or internal validity, to use. However, my decision was to work with scales having 10 or more items, even at the expense of slightly lower internal validity criteria, on the assumption that larger numbers of items produce more discriminating Guttman scales.

Table 2—Comparison of Guttman coefficients for three versions of the retail scale

Guttman coefficient	Original 12-item scale	Six odd-numbered items	Six even-numbered items
Reproducibility	0.88	0.90	0.92
Minimum marginal reproducibility	.72	.71	.73
Improvement	.16	.19	19
Scalability	.56	.65	.70

Stability

At the outset, I noted that an attempt was made to use only SIC codes which applied to all counties. Thus, the intent was to find a set of terms whose internal validity would not be seriously affected by regional disaggregations. To test for this, counties were disaggregaged to Census regions and the Guttman scale coefficients were recomputed for each region using the 12 items in the retail scale (table 3).

There were only slight differences in internal validity across regions. These differences suggest that some improvement in Guttman scales might be made by tailoring new scales to regions for intraregional analyses. Similarly, when the coefficients were recomputed for several of the larger States, internal validity deteriorated slightly. Again, intrastate analyses may be enhanced by tailoring the Guttman model to the particular State. However, comparative analyses across regions, larger States, or various types of counties would not be jeopardized by the instability of the retail scale reported here.

External Validity

Even though the internal validity criteria were not satisfied, in the scale shown, to the extent one would like, they are sufficiently satisfied to ask another, perhaps more important question. That is, does the scale correspond to the real world and measure what it purports to measure, or, does it have external validity?

Table 3—Guttman coefficients for retail scale by Census region

Guttman coefficient	Northeast	North Central	South	West	United States
Reproducibility	0.86	0.88	0.87	0.88	0.88
Minimum marginal reproducibility	.70	.75	.73	.70	.72
Percentage of improvement	.16	.12*	.14	.19*	.16
Scalability	.54	.52	.52	.61	.56

*Does not equal REP minus MMR because of rounding error.

One test of external validity can be made by seeing how the differentiation scales relate to levels of urbanization, given the generally accepted high correlation between urbanization and "development."

Differentiation and Urbanization

A traditional way of examining the external validity of a scale is to measure its abilities against other indexes relating to the same phenomenon. One test of external validity can be made by seeing how the differentiation scales relate to levels of urbanization, given the generally accepted high correlation between urbanization and "development."

This test can be done crudely by comparing Guttman scale scores for counties in Standard Metropolitan Statistical Areas (SMSAs) to those in nonmetro counties. However, Hines, Brown and Zimmer developed a more refined classification of counties which has proven useful in discriminating among them in terms of educational levels, labor force participation, family income, migration rates, fertility, and median age of population (*16*). They first subdivided metropolitan SMSA counties into three categories based on population size in 1970:

(1) *Large* - metro counties with at least 1 million population
(2) *Medium* - metro counties with 250,000 to 999,999 population
(3) *Small* - metro counties with less than 250,000 population.

Similarly, nonmetropolitan counties were subdivided into three categories:

(1) *Urbanized* - nonmetro counties with at least 20,000 aggregate urban population
(2) *Less Urbanized* - nonmetro counties with 2,500 to 19,999 aggregate urban population
(3) *Completely Rural* - nonmetro counties with no urban population.

Metro counties were further classified according to whether they were (1) the "core" county of their respective SMSA, or (2) one of the "fringe" counties in the SMSA.

Table 4 shows the distribution of Guttman scale scores for the retail scale within each of the seven Hines, Brown, and Zimmer urbanization categories. Mean scale scores within categories range from a low of 1.99 for completely rural nonmetropolitan counties to a high of 11.96 for large metro core counties on the 12-item retail scale.[5] Category differences are more striking if median category scores are considered rather than means.[6] Thus, the structural differentiation scale behaves as expected for rather large aggregates of observation.

The dissimilarities in the category distributions are perhaps best seen in the chart, however, which presents the percentage-scale score distribution of the 3,072 county observations for each major urbanization category in the retail scale.[7]

The metro counties show extremely skewed distributions compared with the nonmetro counties. Furthermore, the medium-sized and large metro distributions are quite similar; the lesser metro counties show a slightly less skewed distribution. However, the three nonmetro categories exhibit extremely dissimilar distributions, supporting the idea that the scale discriminates well among nonmetro counties.

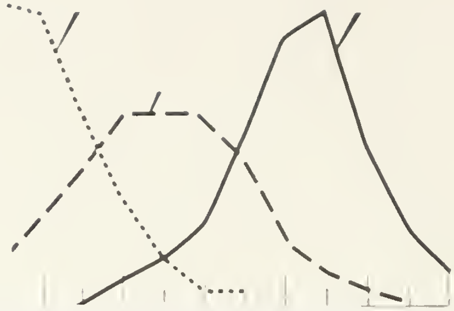
The extreme skewness and larger standard deviations within the metro categories at first glance might seem to indicate a validity problem, as one would generally expect metropolitan counties to cluster tightly at the upper end of the differentiation scale. However, SMSA designations are based on the functional interrelationships among sets of counties, rather than solely on the individual county characteristics.

Thus, counties with predominately rural population characteristics have been included in SMSAs. For example, a county may have a totally rural population (no places of 2,500 or more) and yet be included in an SMSA if 30 percent or more of its labor force commutes to an adjacent core metro county. Once again, the county is not "urban" in character but it depends on a metro county for most of its high-order, commercial functions, as well as much of its basic employment. Thus, some counties with "metro" designations are not necessarily "urban" or "developed." This important difference is of course submerged when simple metro-nonmetro designations are used for inter-county com-

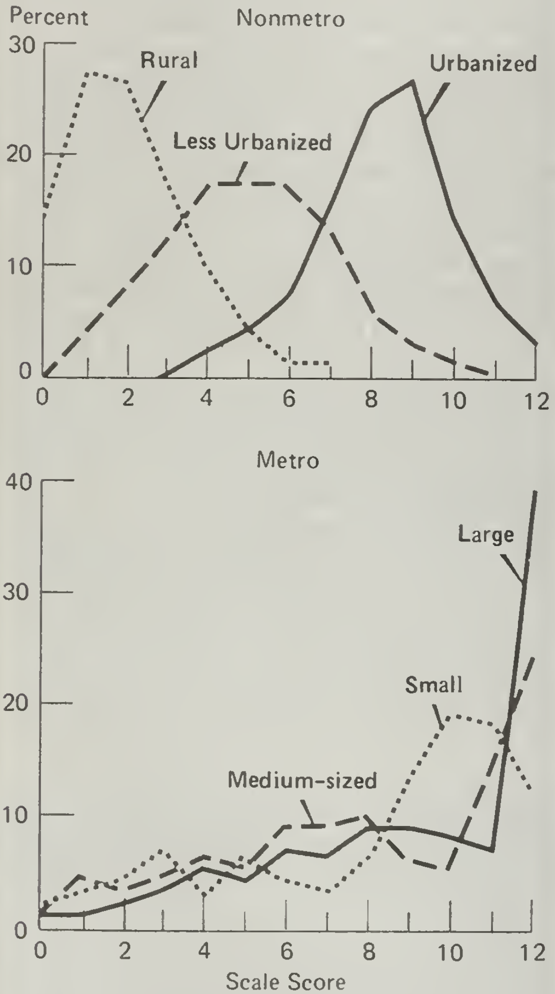
[5] Fringe and core were not disaggregated for the small and medium-sized metro counties on the data tape used to produce this table.

[6] The median may be a more meaningful measure of location here as several of the category distributions are highly skewed.

[7] Metro fringe and core counties are not disaggregated in the chart.



Retail Scale Scores of Counties Distributed by Urbanization Categories*



*Categories developed by Hines, Fred K., David L. Brown, and John M. Zimmer. *Social and Economic Characteristics of the Population in Metro and Nonmetro Counties, 1970.* Econ. Res. Serv., U.S. Dept. Agr. Econ. Rpt. 272, 1975.

parisons. It is revealed vividly when the differentiation concept is applied through the use of scales such as the one presented here.

The heterogeneity of metro counties can also be seen within the large metro category when fringe and core counties are separated. All but 2 of the 47 core SMSA counties, each having over 1 million in population, scored 12 on the retail scale, which indicates the expected lack of variance and high scores in major metropolitan centers. Yet the 127 fringe counties had scores ranging from 1 through 12. Thus, the variance in scale scores for all metro counties may, in fact, be due to the varying nature of fringe counties and not to error in the scale.

While these results are not in and of themselves conclusive, two salient points emerge. First, the differentiation scale discriminated, as logically expected, across categories of nonmetro counties. These categories were constructed based on degree of urbanization. Second, perhaps more importantly, the differentiation scale discriminated *within* both metro and nonmetro categories. This suggests that the scale reveals a dimension often masked in simple metro-nonmetro or "urbanization" categories, as defined by aggregate population and geographic proximity. Structural differentiation thus appears to be empirically independent of the more traditional demographic measures, yet it exhibits a conceptual, logical relationship to these that enhances its external validity.

CONCLUSION

It is perhaps too early to make large claims for either the theoretical succinctness of the structural differentiation concept or for the empirical utility of Guttman scales of differentiation. Yet Guttman scales can be constructed which have reasonable validity and discriminate across, as well as within, urbanization categories based on population characteristics. Further refinement and improvement of both the theory and empirical methods outlined here would seem desirable and potentially fruitful.

Refinement should proceed for at least three other variables bound up with the overall concept of development. First, differentiation must be specified as to its relationship to population size and density and their

. . . if differentiation scales are to be used as social indicators either for research or program purposes, it must be further demonstrated that structural differentiation has some bearing on social well-being or quality of life.

Table 4—Frequency and distribution of retail scale scores by urbanization categories

Scale score	Nonmetro						Metro								United States	
	Rural		Less urban		Urban		Lesser		Medium		Fringe		Core			
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
0	120	14	5	0			3	2	2	1	1	1			131	4.3
1	235	27	52	4			6	3	10	4	1	1			304	9.9
2	221	26	99	8	1	0	7	4	7	3	3	2			338	11.0
3	152	18	159	12	1	0	12	7	10	4	6	5			340	11.1
4	82	10	221	17	6	2	6	3	16	6	8	6			339	11.0
5	31	4	218	17	12	4	11	6	14	5	7	6			293	9.5
6	9	1	223	17	22	7	7	4	22	9	13	10			296	9.6
7	5	1	168	13	49	15	6	3	23	9	10	8			261	8.5
8			77	6	77	24	10	6	25	10	15	12			204	6.6
9			43	3	85	26	23	13	15	6	16	13			182	5.9
10			14	1	45	14	34	19	14	5	14	11			121	3.9
11			1	0	20	6	32	18	37	14	11	9	2	4	103	3.4
12					9	3	21	12	63	24	22	17	45	96	160	5.2
Total	855		1,280		327		178		258		127		47		3,072	100
Mean	1.99		4.98		8.33		8.15		8.21		8.10		11.96		5.19	
S.D.	1.42		2.05		1.71		3.40		3.42		3.02		.20		3.30	
Median	1.33		4.48		7.94		8.91		8.00		7.97		11.48		4.29	

*Based on work by Hines, Brown, and Zimmer (18).

Note: N = number.

changes. Despite the fact that differentiation and population size and density can be kept conceptually distinct, their empirical interrelationship cannot be ignored. Second, the concept of differentiation must be more carefully articulated as to how it relates to economic growth and the processes of rural development. Is maximum differentiation always desirable? If not, what sort of optimality is desired?

Finally, if differentiation scales are to be used as social indicators either for research or program purposes, it must be further demonstrated that structural differentiation has some bearing on social well-being or quality of life. Part of the success of this enterprise, of course, depends on the development of appropriate indicators of well-being and quality of life as well as improved indexes of differentiation.

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Implications of Reimbursement Policies for the Location of Physicians

by James R. Cantwell*

A simple model of physician migration predicts a positive relationship between physician fees and the number of physicians in an area and a negative relationship between physician fees and area population-physician ratios. The strong empirical support for this model suggests that Government health insurance programs could be used to encourage physicians to locate in scarcity areas.

Keywords:

Physician location
Medicare
rural health care

The two major Federal health insurance programs which began in the midsixties—Medicare for the elderly and Medicaid for some of the Nation's poor—may have contributed to a more uneven spatial distribution of physicians in the United States. First, the programs have increased total demand for physician services, while fixed labor and capital (in the short run) have constrained supply. As a result, the programs have increased quasi-rents to physicians and contributed to high physician incomes in adequately served and perhaps overly served areas. These changes have thus contributed to a more uneven distribution of physicians. (This argument was first advanced by DeVise (*6*)).[1]

A second and potentially more serious spatial impact of the programs may have occurred because of the substantially lower third-party reimbursement levels in rural areas than in urban areas. Differential reimbursement rates appear to represent statistically significant determinants of the availability of physicians (as measured by physician-population ratios (*9*, *1*, *11*).

OBJECTIVES

How reimbursement restrictions influence physicians' decisions on their location has not been examined in the literature. Investigation of this impact represents the primary objective of this article. In fiscal year 1977 alone, Medicare and Medicaid programs accounted for $5.4 billion in Federal expenditures for physician services (*8*).

The secondary objective is to examine characteristics of reimbursement areas used by Medicare Part B carriers.[2] The examination will focus on how low physician fees in rural areas affect the availability of physician services. Results for these objectives are important for evaluating third-party reimbursement practices, especially Medicare-Medicaid prevailing charge policies.[3] Contrary to the finding of most recent research on the determinants of the location of physicians (*4*), economic factors will be shown to have considerable impact on the distribution of physicians.

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[1] Italicized numbers in parentheses refer to items in References at the end of this article.

[2] A Medicare Part B (Supplemental Medical Insurance) carrier is an agency or organization (perhaps a Blue Shield plan or commercial health insurer) which has contracted to administer various aspects of the program, including claims payment.

[3] The prevailing charge is one key determinant to Medicare maximum reimbursement levels. Program benefits cannot exceed 80 percent of the reasonable charge (after a $60 deductible is met), which, in turn, is limited by the prevailing charge in the locality. In *A Discursive Dictionary of Health Care*, "prevailing charge" is defined as:

> A charge which falls within the range of charges most frequently used in a locality for a particular medical service or procedures. . . . Current Medicare rules state that the limit of an area's prevailing charge is to be the 75th percentile of the customary charges for a given service by the physicians in a given area.

The "customary charge" is defined as:

> Generally, the amount which a physician normally or usually charges the majority of his patients. Under Medicare, it is the median charge used by a particular physician for a specified type of services during the calendar year preceding the fiscal year in which a claim is processed.

A simple model of physician migration predicts a positive relationship between physician fees and the number of physicians in an area and a negative relationship between physician fees and area population-physician ratios. The strong empirical support for this model suggests that Government health insurance programs could be used to encourage physicians to locate in scarcity areas.

DATA SOURCES

Supporting data come from the American Medical Association's Ninth Periodic Survey of Physicians, fall 1974, the latest year for which such information was available to the author. The questionnaire was mailed to 10,169 randomly selected, nonfederal, office-based physicians in the United States—AMA members and nonmembers. A usable sample size of approximately 5,000 was achieved after several mailings. Data were used to estimate Standard Metropolitan Statistical Area (SMSA) and county medical characteristics. Two separate files were created—one for SMSAs and one for nonmetropolitan counties.

REIMBURSEMENT AREAS

The various Medicare Part B carriers have options in drawing geographic boundaries within a State for purposes of calculating prevailing charges. Different carriers use different approaches. For example, in California, the two carriers established 28 localities, each composed of contiguous areas. In Massachusetts, two localities were formed—urban and suburban/rural. In Colorado, the carrier has made the State the prevailing charge locality.

Two alternative philosophies might guide persons trying to decide whether geographic (and specialty) differentials are to be incorporated in a fee-for-service reimbursement system. Reimbursement might be structured to reflect physician fees in the private market. This approach will be called *passive*. Or, the reimbursement structure could be used to influence physician location (and specialty) choices. This second approach will be called *active*.

A strong case has recently been developed that current Federal programs to finance health care contain substantial bias against rural residents (*5*). This bias stems partly from (1) eligibility requirements which insure broad coverage of poor, central-city residents and (2) a passive reimbursement fee structure.

A passive reimbursement structure would maintain urban-rural fee differentials. Whether any such differentials should be maintained in an active reimbursement structure is not clear, as these differentials may be largely attributable to differences in patients' incomes and extent of insurance coverage between the areas (*12*).

A MODEL OF PHYSICIAN LOCATION

To better understand the implications of Medicare reimbursement differentials on physician location, the relationship between physicians' fees and population-physician ratios will be explored. First, however, let us briefly review "price" and "quantity" in the market for physician services.

In their work on income from professional practice, Friedman and Kuznets argue that:

> In an analysis of medical and dental services, however, it is not obvious even what the relevant unit of service supplied or demanded is. And no matter how this 'unit' is defined, there is clearly no single price at which it sells; rather, there is a frequency distribution of prices. . . .
>
> *i The supply curve*. On the side of supply, the relevant 'unit' seems to be the individual practitioner . . . The total amount of service the profession stands ready to offer depends primarily on the number of practitioners. . . .
>
> The "price" that determines the "supply" of entrants is clearly the income or returns that individuals count on receiving. . . .
>
> If we abstract from all factors affecting the choice of a profession other than actuarial ones, the supply of new entrants depends solely on the relative arithmetic mean returns and costs. . . .
>
> *ii The demand curve*. On the side of demand as well as supply there is no easily specified 'unit' or single 'price'. . . . The only thing that seems relevant is the total sum that consumers as a whole are willing to spend for medical services. . . .
>
> We may, therefore, conceive of a demand curve for 'physicians' in which the 'price' is the average gross income per physician and the 'quantity', the number of physicians. But we cannot use this demand curve for our purposes. It is the average *net* rather than *gross* income that is the relevant figure to the prospective

practitioner. However, to each possible value of total gross income corresponds a fairly determinant value of total net income. We can therefore pass from a demand curve in which the 'price' is the average gross income to one in which the 'price' is the average net income (7).

One may reasonably assume that physicians will distribute themselves spatially so that their rate of return on their skills and abilities will be equalized, except for differences attributed to their transportation costs and differences which reflect differing amenities between regions. Therefore, no significant empirical relationship should be expected between physicians' net incomes and the stock of physicians in a geographic area if adjustments are made for skill and amenity differentials. However, a significant relationship should be expected between the stock of physicians and the determinants of (1) total payments to physicians, namely fees and number of visits by patients, and (2) costs of maintaining a medical practice.

Following Rimlinger and Steele (R-S), assume initially that physicians attempt to maximize net incomes (*13*). Although it provides the foundation for the following analysis, the R-S model did not include explicitly the role of physicians' fees and costs in determining area population-physician ratios. The following analysis does include this role explicitly.

After beginning with an identity relationship, we move to an equilibrium condition by imposing the assumption that physicians migrate until net incomes are equalized.

The following notation will be used:

POP_i = population of area *i*.
P_i = average fee per visit by patient in area *i*.
V_i = number of visits by patients per capita per year in area *i*.
MD_i = number of physicians in area *i*.
Y_i = physicians' average net income in area *i*.
C_i = average total costs of conducting business in area *i*.

With capital letters representing national variables, gross expenditures for physicians' services equal gross income to physicians:

$$POP\,(PV) \equiv MD\,(Y+C) \qquad (1)$$

In area *i*,

$$POP_i\,(P_iV_i) \equiv MD_i\,(Y_i+C_i) \qquad (2)$$

If, for equilibrium, physicians' net incomes are to be equal across space, the following equality must hold:

$$Y_i = \bar{Y} \qquad (3)$$

where $\bar{Y}$ is physicians' average net income in the Nation. This equality implies that the number of physicians which area *i* can support in equilibrium is:

$$MD_i = \frac{POP_i\,(P_iV_i)}{\bar{Y} + C_i} \qquad (4)$$

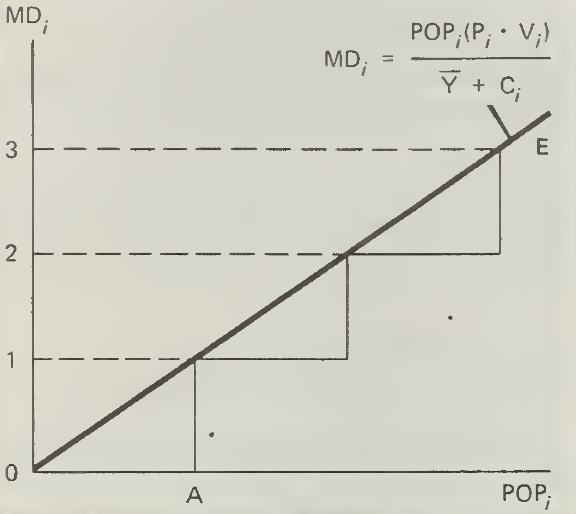
Assume initially that P_i, V_i, and C_i are invariant with location. Because MD_i is restricted to integer values (unless areas share physicians on a part-time basis), the supply of physicians, given by a step function, appears under line OE in the figure. Area *i* would require a population of OA to support a physician. With less population, area *i*'s supply and demand for physician services would not intersect; physician services would be available only with a subsidy.

A Government insurance program, such as an idealized Medicare-Medicaid program, would have at least two effects on equation (4). First, some cases previously treated on a charity basis would now contribute to physicians' revenues, which increases area *i*'s ability to support a physician. But if the market for physician services were initially in equilibrium, the excess demand would cause prices of services to rise, which would lead to higher average income for physicians. Whether a given area gains or loses physicians in the new equilibrium allocation depends on the amount of the area's Medicare-Medicaid receipts compared with the increase in physicians' average income.

Let M_i represent the area's Medicare-Medicaid receipts, which would depend on the number of Medicare-Medicaid eligibles, their utilization patterns, and the average allowable reimbursement per visit to a

The population-physician ratio in an area relates directly to physicians' average net income in the Nation and expenses of their practices in the area, but the ratio relates inversely to physicians' fees in the area and visits per capita.

FIGURE 1
Equilibrium Number of Physicians



physician. With P_i as price net of Medicare-Medicaid outlays, equation (4) will become:

$$MD_i = \frac{POP_i\,(P_iV_i) + M_i}{\bar{Y} + C_i} \qquad (5)$$

If Medicare-Medicaid expenditures and price net of Medicare-Medicaid outlay were available by region, estimates of the quantitative impact of these programs could be obtained. Data are not available for urban or rural areas; thus, empirical testing of the determinants of physician location must rest on the simpler equation (4):

$$\ln MD_i = \ln POP_i + \ln P_i + \ln V_i - \ln(\bar{Y}+C_i) \qquad (6)$$

or:

$$\ln\,(POP_i/MD_i) = \ln\,(\bar{Y}+C_i) - \ln P_i - \ln V_i \qquad (6')$$

The population-physician ratio in an area relates directly to physicians' average net income in the Nation and expenses of their practices in the area but the ratio relates inversely to physicians' fees in the area and visits per capita.[4]

EMPIRICAL RESULTS

Data are available for variables in equations (6) and (6′) for 1974. The values for population-physician ratios range from 414 for the largest SMSAs to 2,438 for the smallest nonmetropolitan counties (table 1). Physicians' mean net incomes and total expenses for practices vary little across counties and SMSAs (table 2). However, their fees and number of visits from patients per week differ considerably (table 2).[5]

The null hypothesis of a negative or zero relationship between the stock of physicians and their fees was tested against the hypothesis of a positive relationship. Cross sectional, single-equation estimates of (1) the stock of physicians equation and (2) the population-physician equation were obtained. Observations were restricted first to SMSAs (tables 3-5)[6] and second to nonmetropolitan counties, aggregated and by State (table 6). The SMSA results are reported separately for all SMSA physicians (table 3), all SMSA specialist physicians (table 4), and all SMSA general-practice physicians (table 5). In all four tables, the first column of results gives estimates from equation 6. The second column reports results when the estimates are for quality of life in the area, the number of graduates of the State's medical schools, and the amount of hospital capital in the area. The final column presents estimates of the impact of physicians' fees on the population-physician ratio (equation 6′).

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[4] Population-physician ratios rather than the reciprocal are used because they convey physicians' work load better than the more usual statistic, physicians per 100,000 population. In addition, physicians per 100,000 population is an artificial construct when the area to which the statistic applies has fewer than 100,000 people.

[5] Spatial variation in physicians' fees is discussed in (*3, 2*).

[6] Tables 3 through 6 appear at the end of the article to avoid breaking up the text.

In sum, these results demonstrate that the number of physicians in an area is strongly influenced by the determinants of their net income.

Table 1—Population-physician ratios, by SMSA and county size, 1974

SMSA and county classification	Population		Nonfederal physicians		Population-physician ratio
	No.	*Pct.*	*No.*	*Pct.*	
United States total	211,392	100.0	321,089	100.0	658.4
SMSAs	153,893	72.8	277,553	86.4	554.5
Greater than 5 million	23,466	11.1	56,740	17.7	413.6
1 million to 5 million	62,726	29.7	121,500	37.8	516.3
500,000 to 1 million	27,953	13.2	44,360	13.8	630.1
50,000 to 500,000	39,748	18.8	54,953	17.1	723.3
Other than SMSAs	57,499	27.2	43,536	13.6	1,320.7
Greater than 50,000	4,279	2.0	4,299	1.3	995.3
Potential SMSA*	16,517	7.8	16,925	5.3	975.9
25,000 to 50,000	16,337	7.7	12,240	3.8	1,334.7
10,000 to 25,000	15,504	7.3	8,078	2.5	1,919.3
Under 10,000	4,862	2.3	1,994	.6	2,438.3

*Potential SMSA is a Sales Management term. See Roback, G. *Distribution of Physicians in the U.S., 1973.* Am. Medical Assoc., Chicago, 1974.

Source: Calculation using the Area Resource File, U.S. Dept. Health, Educ., and Welfare.

Equations (6) and (6′) are each based on an identity if (3) holds. We could use physicians' income in the area rather than physicians' average income in the Nation ($\bar{Y}$). With the constant suppressed, the estimated coefficients in column one would then all be "1" except the coefficient $\bar{Y} + C_i$, which would be "−1". Using $\bar{Y}$ rather than Y_i allows incorporating the behavioral assumption that physicians migrate until net incomes are equalized. This approach permits examination of pricing policies as determinants of the number of physicians in an area. The estimated coefficient of P_i in column one is positive and highly significant at the 1-percent level in all four tables. The other three estimated coefficients for the variables POP, V_i, and $\bar{Y} + C_i$ also differ significantly from zero at the 1-percent level, each with the expected sign. In sum, these results demonstrate that the number of physicians in an area is strongly influenced by the determinants of their net income.

In the second column three other variables are added. MDOUTPUT tests the effect of increasing the number of physicians who graduate from medical schools within a State on the supply of physicians to that State. If increasing the number of graduates is an effective policy, a positive coefficient would be expected in the stock of physicians equations (column two). INDEX and the associated dummy variables DSIZE1 and DSIZE2 test the effect of "quality of life" on the supply of physicians. A positive coefficient for INDEX would be expected in the stock of physicians equations. BEDS tests the effect of the stock of hospital equipment, as

If prevailing charge levels are established at higher levels in urban than in rural areas, we can expect availability of physicians' services in rural areas to be affected adversely.

Table 2—Physicians' net income, expenses of practices, visits by patients, 1974

SMSA and county classification	Mean estimated net income	Mean estimated expenses of practices	Mean total visits by patients per week
	Dollars		*Number*
United States	51,224	35,351	125.8
SMSAs			
Greater than 1 million	49,964	33,162	104.8
50,000 to 1 million	53,520	37,522	128.4
Non-SMSAs:	50,380	37,423	166.2

Source: Cantwell, J. R., ed. ***Profile of Medical Practice, 1975-76 Edition***, Am. Medical Assoc., 1976, tables 43, 57, and 63.

reflected by the number of beds, on the supply of physicians. A positive coefficient for BEDS would be expected in the stock of physicians equation.

The estimates for MDOUTPUT suggest that increasing the number of physicians graduating from a State's medical schools will not increase the number of physicians serving that State. Indeed the sign of the coefficient in all stock of physicians equations is negatively related with a coefficient which is not significantly different from zero. Similarly, the population-physician ratio is not significantly related to the level of output from medical schools located in the State.

The coefficients for INDEX indicate that physicians are strongly attracted to areas which have a high index on Liu's quality-of-life scale (*10*). This finding holds true for physicians who locate in SMSAs and for those who locate in rural areas. The two size variables, DSIZE1 and DSIZE2, are required, as Liu has separate indexes for small, medium-sized, and large SMSAs. The estimated coefficient for BEDS in the stock of physicians equation is positive in three of the tables (3, 4, and 6) but statistically different from zero only in the first two tables.

Except for the size dummy variables and the BEDS coefficient in table 5, the expected reversal of signs occurs with all variables, when comparing the physician stock equation (6) with the population-physician equation (6′). Note especially the negative and highly significant coefficient of price in all four equations.

CONCLUSIONS

Population size, fees, visits per capita by patients, costs of practices, quality of life in the area, and quantity of hospital capital (measured by the number of beds), all help determine the number of physicians serving the geographic areas studied. Fees have been singled out for special emphasis because of the need to devise reimbursement criteria under Medicare-Medicaid (and NHI in the future) which will not worsen the poor distribution of physicians.

If prevailing charge levels are established at higher levels in urban than in rural areas, we can expect availability of physicians' services in rural areas to be affected adversely. One policy which merits consideration is to actively use the reimbursement system to encourage physicians to locate in areas lacking them. A first step in implementing this policy within the Medicare program would be for the carrier to set limits on prevailing charges which would make them uniform throughout a State.

One policy which merits consideration is to actively use the reimbursement system to encourage physicians to locate in areas lacking them.

Table 3—SMSA physician location equations
(log-log form)

Explanatory variables	Ln (MD)	Ln (MD)	Ln (POPMD)
Ln (POP)	1.0376** (0.0211)	0.7058** (0.0683)	
Ln (P_i)	0.5198** (0.0756)	0.4414** (0.0692)	−0.4286** (0.0722)
Ln (V_i)	0.3879** (0.0429)	0.2736** (0.0420)	−0.3253** (0.0420)
Ln ($\bar{Y}$ + C_i)	−0.3682** (0.1018)	−0.2771** (0.0935)	0.3089** (0.0474)
INDEX		0.1874** (0.0455)	−0.2028** (0.0474)
DSIZE1		0.1199 (0.0860)	0.0632 (0.0780)
DSIZE2		0.0779* (0.0510)	0.0082 (0.0491)
Ln (MDOUTPUT)		−0.0062 (0.0052)	0.0063 (0.0055)
Ln (BEDS)		0.3488** (0.0631)	−0.1184** (0.0349)
(CONSTANT)	−9.91	−8.11	9.96
R^2	.95	.96	.56
$\bar{R}^2$	.95	.96	.55
F	F(4,197) = 957.8**	F(9,192) = 534.4**	F(8,193) = 31.3**

*Significant at the 5-percent level (one-tail).
**Significant at the 1-percent level (one-tail).

Numbers in parentheses are standard errors of the parameter estimates.

- MD is the total number of nonfederal, patient care physicians in the SMSA,
- POPMD is POP ÷ MD,
- POP is the SMSA population,
- P_i is the mean price in cents of a followup office visit in the SMSA,
- V_i is mean total visits per capita, in the SMSA,
- $\bar{Y}$ + C_i is 51 plus mean practice expenses (in $1,000) in the SMSA,
- INDEX is the value of the Liu quality-of-life index for the SMSA,
- DSIZE1=1 if the SMSA population is greater than 500,000, 0 otherwise,
- DSIZE2=1 if the SMSA population is greater than 200,000 but less than 500,000, 0 otherwise,
- MDOUTPUT is the total number of surviving graduates of medical schools located in the State, and
- BEDS is the number of hospital beds in the SMSA.

". . . much unclear writing is based on unclear or incomplete thought. It is possible with safety to be technically obscure about something you haven't thought through. It is impossible to be wholly clear on something you do not understand. Clarity thus exposes flaws in the thought. The person who undertakes to make difficult matters clear is infringing on the sovereign right of numerous economists, sociologists, and political scientists to make bad writing the disguise for sloppy, imprecise, or incomplete thought . . .

Table 4—SMSA Specialist location equations
(log-log form)

Explanatory variables	Ln (SPEC)	Ln (SPEC)	Ln (POPSPEC)
Ln (POP)	1.0363** (0.0230)	0.7007** (0.0769)	
Ln (P_i)	0.5696** (0.0823)	0.5075** (0.0770)	−0.4900** (0.0796)
Ln (V_i)	0.4724** (0.0442)	0.3587** (0.0450)	−0.4134** (0.0443)
Ln ($\bar{Y} + C_i$)	−0.4218** (0.1140)	−0.3296** (0.1074)	0.3628** (0 1109)
INDEX		0.1722** (0.0507)	−0.1877** (0.0523)
DSIZE1		0.1246 (0.0960)	0.0608 (0.0863)
DSIZE2		0.0682 (0.0569)	0.0186 (0.0543)
Ln (MDOUTPUT)		−0.0077 (0.0058)	0.0077 (0.0061)
Ln (BEDS)		0.3499** (0.0712)	−0.1138** (0.0387)
(CONSTANT)	−10.24	−8.51	10.35
R^2	.95	.96	.60
$\bar{R}^2$	.94	.95	.58
F	F(4,197) = 860.6**	F(9,192) = 456.0**	F(8,193) = 36 4**

**Significant at the 1-percent level (one-tail)

Numbers in parentheses are standard errors of the parameter estimates.

- SPEC is the total number of nonfederal, patient care specialist physicians in the SMSA,
- POPSPEC is POP ÷ SPEC,
- POP is the SMSA population,
- P_i is the mean price in cents of a followup office visit in the SMSA,
- V_i is mean total visits per capita in the SMSA,
- $\bar{Y} + C_i$ is 54 plus specialist mean practice expenses (in $1,000) in the SMSA.
- INDEX is the value of the Liu quality-of-life index for the SMSA,
- DSIZE1=1 if the SMSA population is greater than 500,000, 0 otherwise,
- DSIZE2=1 if the SMSA population is greater than 200,000 but less than 500,000, 0 otherwise,
- MDOUTPUT is the total number of surviving graduates of medical schools located in the State, and
- BEDS is the number of hospital beds in the SMSA.

. . . In the case of economics there are no important propositions that cannot be stated in plain language. Qualifications and refinements are numerous and of great technical complexity. These are important for separating the good students from the dolts. But in economics the refinements rarely, if ever, modify the essential and practical point."

John Kenneth Galbraith
The Atlantic Magazine
March 1978

Table 5—SMSA general practitioner location equations (log-log form)

Explanatory variables	*Ln* (GP)	*Ln* (GP)	*Ln* (POPGP)
Ln (POP)	1.0100** (0.0174)	1.0672** (0.0584)	
Ln (P_i)	0.1752** (0.0659)	0.1181** (0.0644)	−0.1228** (0.0643)
Ln (V_i)	0.3840** (0.0320)	0.3644** (0.0309)	−0.3651** (0.0309)
Ln ($\bar{Y} + C_i$)	−0.2219** (0.0798)	−0.1936** (0.0774)	0.1917** (0.0774)
INDEX		0.2001** (0.0406)	−0.1946** (0.0404)
DSIZE1		−0.0032 (0.0764)	−0.0399 (0.0666)
DSIZE2		0.0422 (0.0453)	−0.0618* (0.0421)
Ln (MDOUTPUT)		−0.0006 (0.0047)	0.0005 (0.0047)
Ln (BEDS)		−0.0355 (0.0522)	−0.0145 (0.0289)
(CONSTANT)	−8.96	−9.38	8.94
R^2	.96	.96	.49
$\bar{R}^2$	.96	.96	.47
F	F(4,197) = 1,101.7**	F(9,192) = 542.3**	F(8,193) = 23.2**

*Significant at the 5-percent level (one-tail)
**Significant at the 1-percent level (one-tail)

Numbers in parentheses are standard errors of the parameter estimates.

- GP is the total number of nonfederal, patient care general-practice physicians in the SMSA,
- POPGP is POP ÷ GP,
- POP is the SMSA population,
- P_i is the mean price in cents of a followup office visit in the SMSA,
- V_i is mean total visits per capita in the SMSA,
- $\bar{Y} + C_i$ is 44 plus GP mean practice expenses (in $1,000) in the SMSA.
- INDEX is the value of the Liu quality-of-life index for the SMSA,
- DSIZE1=1 if the SMSA population is greater than 500,000, 0 otherwise,
- DSIZE2=1 if the SMSA population is greater than 200,000 but less than 500,000, 0 otherwise,
- MDOUTPUT is the total number of surviving graduates of medical schools located in the State, and,
- BEDS is the number of hospital beds in the SMSA.

$$MD_i = \frac{POP_i(P_i \cdot V_i)}{\bar{Y} + C_i}$$

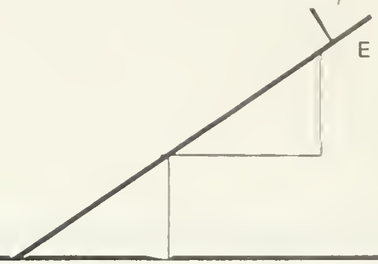

Table 6—Rural physician location equations (log-log form)

Explanatory variables	*Ln* (MD)	*Ln* (MD)	*Ln* (POPMD)
Ln (POP)	1.1419** (0.0600)	1.0706** (0.0972)	
Ln (P_i)	0.5504** (0.1673)	0.4322** (0.1730)	−0.4554** (0.1691)
Ln (V_i)	0.4608** (0.0869)	0.4843** (0.0919)	−0.4572** (0.0835)
Ln ($\bar{Y} + C_i$)	−0.4216** (0.2077)	−0.4093** (0.2052)	0.3808** (0.2003)
INDEX		0.4383** (0.1760)	−0.2808** (0.1751)
Ln (MDOUTPUT)		−0.0102 (0.0091)	0.0101 (0.0091)
Ln (BEDS)		0.1188 (0.1033)	−0.1790** (0.0624)
(CONSTANT)	−11.8	−10.70	10.50
R^2	.90	.92	.55
$\bar{R}^2$	.89	.91	.49
F	$F(4,45) = 105.2$**	$F(7,42) = 69.4$**	$F(6,43) = 8.8$**

**Significant at the 1-percent level (one-tail)

Numbers in parentheses are standard errors of the parameter estimates.

- MD is the total number of nonfederal, patient care physicians in the county,
- POPMD is POP ÷ MD,
- POP is the county population,
- P_i is the mean price in cents of a followup office visit in the county,
- V_i is mean total visits per capita in the county,
- $\bar{Y} + C_i$ is 51 plus mean practice expenses (in $1,000) in the county.
- INDEX is the value of the Liu quality-of-life index for the State in which the county is located,
- MDOUTPUT is the total number of surviving graduates of medical schools located in the State, and
- BEDS is the number of hospital beds in the county.

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In Earlier Issues

In general, demand curves for farm products that are perishable and that have a single major use can be approximated by single-equation methods. Most livestock products and fresh fruits and vegetables (and, pragmatically, feed grains and hay) fall in this category. Such products contribute more than half of total cash receipts from farm marketings. With other farm products—as wheat, cotton, tobacco, and fruits and vegetables for processing—two or more simultaneous relationships are involved in the determination of free-market prices. The multiple-equation approach of the Cowles Commission may be fruitful in dealing with such commodities. Even in the case of wheat or cotton, however, it is possible to approximate certain elements of the total demand structure by means of single equations.

Karl A. Fox
July 1951, Vol. 3, No. 3, p. 70

Research Review

AN APPLICATION OF RIDGE REGRESSION WITH VERIFICATION OF NEW PROCEDURES

By Mike Belongia*

INTRODUCTION

In a recent attempt to calculate price and income elasticities for expenditures on meals and snacks, one of the most common problems of least squares regression was encountered. Data included in the statistical model were highly collinear. The problem was particularly troublesome because the regressors, income and a measure of relative prices, were both needed to derive the desired elasticities. The standard approach, elimination or combination of regressors, was clearly unacceptable.

As the problem was statistical in nature and did not involve model specification, an alternative method of estimation was used in place of ordinary least squares (OLS): Hoerl and Kennard's technique of ridge regression, especially designed to handle problems of multicollinearity (*3*, *4*).[1] The purpose of this note is to outline the general ridge estimator, show its application in solving the elasticity problem mentioned above, and finally, test a new technique for evaluating the selection of ridge estimates.

RIDGE REGRESSION

To illustrate the concept of ridge regression, first consider the OLS estimator $\hat{B}$:

$$\hat{B} = (X'X)^{-1} X'Y \qquad (1)$$

where X is an $n \times p$ matrix of regressors standardized so that $X'X$ is a nonsingular correlation matrix, Y is an $n \times 1$ vector of observations on the dependent variable measured in terms of deviations from its mean, and $\hat{B}$ is a $p \times 1$ vector of calculated values for the true but unknown parameters, B. When problems of multicollinearity exist, the $X'X$ matrix has one or more small eigenvalues.[2] Because the literature holds many derivations of this relationship, let it suffice to say here that if the extent to which the vectors of the X matrix deviate from orthogonality increases, the eigenvalues become smaller and the distance between $\hat{B}$ and B can be expected to increase. That is, as the system deviates from orthogonality, the disparity between the true parameters and the estimated parameters will increase.

To overcome this problem, small biases may be added to the diagonal of the $X'X$ matrix, biases which give $X'X$ the characteristics of orthogonality. Thus, the ridge estimator of Hoerl and Kennard is:

$$B^* = (X'X + kI)^{-1} X'Y \qquad (2)$$

where k is the amount of bias and I is a $p \times p$ identity matrix. Of course, when $k = 0$, we have the OLS estimator.

Some may quarrel with the use of biased estimators. However, as Judge, Bock, and Yancy point out:

> The notion of unbiasedness which has been accepted by or perhaps forced on applied workers, although intuitively plausible, is an arbitrary restriction or property and has no direct connection with the loss due to incorrect decisions (*5*).

The advantage of reducing multicollinearity at the expense of introducing bias is clear when it is recalled that highly multicollinear data series are often the direct cause of "incorrect" signs on coefficients and of severe changes in the magnitudes of parameters after only negligible changes in the data set such as the addition of an extra observation. This problem is especially important when the magnitudes of the coefficients have economic interpretations.[3]

THE RESEARCH PROBLEM

Recently, a consistent and comprehensive data series for total U.S. food expenditures has been presented (*1*, *6*). Previous estimates of price and income elasticities for food expenditures typically had been calculated using inconsistent subsets of total food expenditures. These subsets do not include all foods.[4] Thus, the new

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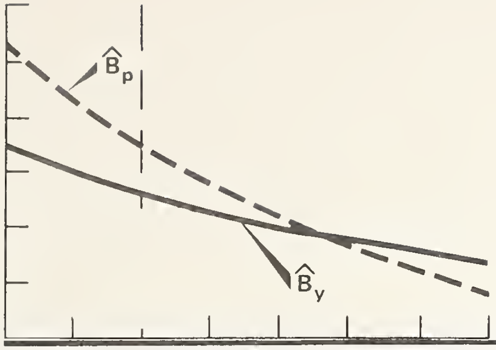
[1] Italicized numbers in parentheses refer to items in References at the end of this note.

[2] Eigenvalues are values of parameters for which a differential equation has a nonzero solution satisfying given conditions.

[3] See (*2*), for example.

[4] The two most widely used series have been the personal consumption expenditures reported by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and the expenditures on U.S. farm-produced food published by ESCS, U.S. Department of Agriculture (often referred to as the "marketing bill"). The BEA series includes only



series provided the first opportunity to calculate elasticities truly representing *total* food expenditures for major expenditure categories, including the meals and snacks component. Few empirical studies have included this category of food expenditures, and existing estimates often have been based on inconsistent data or calculated from functions that do not provide both price and income elasticities.

The regressors used to estimate the elasticities for expenditures on meals and snacks were found to be highly correlated and they are the basis for the examples presented here.[5] The model estimated was:

EXPMS = *f*(Y, P) (3)

where:

EXPMS = *ln* [(per capita expenditures on meals and snacks ÷ all commodities CPI) x 100]

Y = *ln* [(per capita disposable income ÷ CPI for all commodities) x 100]

P = *ln* [(CPI for food away from home ÷ CPI for nonfood items) x100]

Although rarely estimated in this form, price can be used as a regressor in expenditure-dependent functions to determine quantity-price elasticities.[6] The model was estimated using annual time-series data from 1954 through 1977.

OLS RESULTS

The results obtained from estimating equation (3) by OLS are presented in the table. Equation (3) yields parameter estimates apart from those suggested by other empirical studies. Expenditures on meals and snacks appear to be less sensitive to price changes than are expenditures on all food although one would expect meals and snacks to be the most price sensitive expenditure category. The income elasticity is reasonable compared with those in other food expenditure studies.

THE RIDGE REGRESSION ESTIMATES

The elasticities derived from the first set of ridge regression parameter estimates are as follows:

Implied quantity-price elasticity	Expenditure-income elasticity
−0.355	0.560

An appropriate value for *k* was determined by the criteria established in (*3*). At that value of *k*, (1) parameter estimates will become stable and the system will have orthogonal characteristics; (2) the parameters will be of correct sign and reasonable magnitude; and (3) although R^2, by necessity, is lowered, the residual sum of squares will not be increased to unreasonable levels. Finally, a plot of B* against their associated values for the alternative levels of k, called the "ridge trace," helps in visualizing the point at which the system stabilizes. As originally formulated by Hoerl and Kennard, the selected value of *k* should be at a point associated with

personal consumption expenditures; it excludes business meals, institutional purchases, home production, and the value of food purchased through military exchanges or Government food programs. By contrast, the marketing bill excludes the value of imports, fish, and all foods not originating on U.S. farms. Neither is a measure of *total* food expenditures.

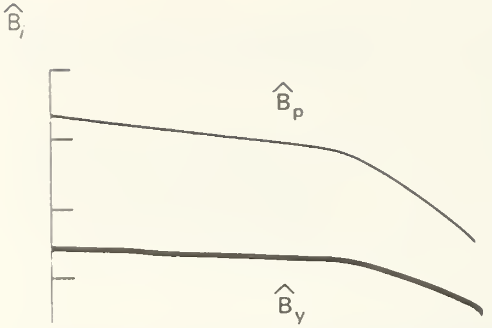
[5] The simple correlation coefficient between the two independent variables was 0.98.

[6] See (*10*) for the derivation.

Results of the OLS parameter estimation [1]

Expenditure-dependent function	Implied quantity-price elasticity	Expenditure-income elasticity
(3) EXPMS = 0.831 x P + 0.647 x Y (.26)[a] (.121) R^2 = .99 F = 954.11 S_y = 0.19 MSE = .00038	[2] −0.169	0.647

[1] Values in parentheses are standard errors. [2] Calculated from the formula: expenditure-price elasticity = quantity - price elasticity + 1.



the flattening of the two curves (3, 4). The ridge trace in figure 1 suggests that the system stabilizes at a value of k greater than 0.5.

However, McDonald and Galarneau have found that the ridge trace is a poor indicator of stability (7). Vinod has confirmed these suspicions by showing that "the absolute value of the changes in B* for a given change in k is smaller for large k. Thus, the k scale has the unfortunate property that the ridge trace may *appear* to be more stable for larger k even for completely orthogonal data" (8). Vinod then derived a new plot consisting of B* against a new scale for the horizontal axis called the "multicollinearity allowance," or m, which is defined as:

$$m = p - \sum_i \lambda_i / (\lambda_i + k_i)$$

where p is the number of regressors, λ_i are the eigenvalues of the $X'X$ matrix, and k_i are the values of k for which B* are evaluated. Essentially, m indicates the deficiency in the rank of $(X'X)$. The ratio of m/p can be thought of as analogous to Theil's measure of the relative contributions of the sample and *a priori* information to the *a posteriori* precision of B* (8).

This new plot, shown in figure 2, indicates that selecting a k based on the Hoerl-Kennard ridge trace can lead to the selection of an inflated value of k. For a point where the slope of the curves changes only slightly, or not at all, the plot derived by Vinod suggests a value associated with $m = 1.083$ or $k = 0.2$, instead of $k = 0.5$ as suggested by figure 1. This discrepancy between values for k would change the elasticities for equation (3) from 0.560 and −0.355 to 0.387 and −0.726, respectively. While both changes are substantial, the price elasticity is changed by the larger amount, a factor of 2.

Vinod also derived a new statistic which indicates which value for k moves the system closest to orthogonality. This measure, the Index of Stability of Relative Magnitudes (ISRM) is defined for $m < p$ as:

$$\text{ISRM} = \sum_i \left[(p\,\delta_i^{\,2}/\bar{S}\,\lambda_i) - 1\right]^2$$

where p = the number of regressors, λ = the eigenvalues of $X'X$, $\delta i = \lambda_i/(\lambda_i + k_i)$ and

$$\bar{S} = \sum_i \lambda_i/(\lambda_i + k)^2.$$

ISRM, which will be zero for completely orthogonal systems, provides one more indicator of an appropriate amount of bias to be introduced into the estimator. That is, the value of k which produces the smallest ISRM will make the system most like an orthogonal system. When $k = 0.2$, the value suggested by the plot of m, the smallest ISRM is produced. Finally, note that $k = 0$, the OLS estimator, produces the largest ISRM. Together, the plot of m, the ISRM and the *a priori* considerations concerning the signs and magnitudes of coefficients all support the choice of $k = 0.2$ and the resulting quantity-price elasticity of −0.355 and expenditure-income elasticity of 0.560. For the derivations of these statistics and other implications for the selection of m and what m represents, see (8).

In Earlier Issues

D. Howard Doane concludes that the greatest opportunity for the American farmer is to perform some of the services now handled by the "middleman," and thus retain for himself a part of the margin between the price paid for raw farm products and the price paid by the consumer. . . . He presents many ideas on how farmers might profitably expand (through vertical integration). . . . He takes some verbal sideswipes at horizontal integration.

Carl P. Heisig
(Review of: *Vertical Farm Diversification* by D. Howard Doane)
April 1951, Vol. 3, No. 2, p. 62

FIGURE 1
Discrepancy Between Old and New Methods for Selecting K

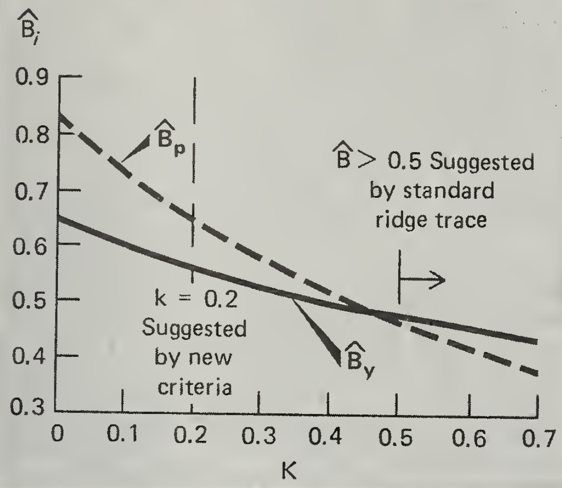
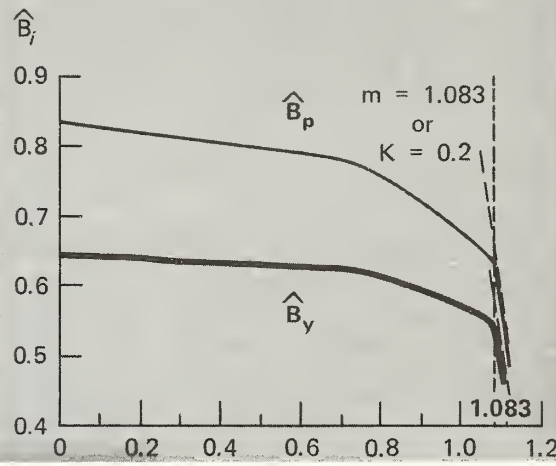


FIGURE 2
Vinod's m Statistic and Suggested Values for $\hat{B}$



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CHANGES IN THE PRESENTATION OF THE NATIONAL I/O TABLES

*By Gerald Schluter and Gene K. Lee**

Events within the U.S. food and fiber system during the seventies have constantly reminded us of the many close ties both among its subsectors and between it and the rest of the economy. The national input-output (I/0) tables periodically supply measures of these close ties. With the publication of the most recent table, the interindustry accounts for the 1972 U.S. economy, the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) has adopted much of the format of the United Nation's System of National Accounts (SNA) as well as incorporating other changes in the definitions and procedures used in earlier tables.[1] This note reviews the SNA approach to I/O accounting, identifies the other changes, contrasts the new with the previous presentation, and discusses ways in which the latter change may affect users of I/O data.

THE SYSTEM OF NATIONAL ACCOUNTS

First published by the United Nations in 1953,[2] the System of National Accounts (SNA) was revised, after 15 years of intensive review, in 1968.[3] The system integrates and links the definition and classification of product flows and stocks into a coherent structure within an economy. Industries, and therefore commodities, are grouped using a single international standard classification of all economic activities. The system also serves as a basis for reporting of comparable national accounting data to the United Nations and other international bodies. Finally, it provides for coordination of international guidelines and standards relating to more specialized bodies of economic, financial, and other statistics.

In a simplified form, the system is designed to present all transactions (flows) in a national economy in four national accounts. These are production (domestic product account), consumption (income and outlay account), accumulation (capital transaction account), and the rest of the world (balance of payments account). Assets and liabilities (stocks) are represented by opening and closing balance sheets; they are linked by revaluations that adjust assets previously acquired or liabilities previously issued to the prices existing at the closing date.

THE INPUT-OUTPUT ACCOUNTS

Within the national accounting format, the input-output accounts are an expansion of the production account. This account can be specified by commodity or industry. A commodity production account reports production of a specific commodity regardless of industry origin. Similarly, an industry production account reports output of a given industry, including its primary and secondary products. Unfortunately, the data required for constructing an I/O table are seldom available systematically in either commodity or industry form. In fact, users of I/O tables usually want both commodity and industry analyses.[4] The I/O accountant thus must allocate the required inputs of a commodity (or service) among the several possible industrial sources of the commodity, unless all of the commodity is primary output of one industry.

ADVANTAGES OF SNA APPROACH

To illustrate changes made by the SNA approach, consider the production of ice cream within the Fluid Milk industry (SIC 2026). Ice cream is a primary product of SIC 2024, Ice Cream and Frozen Desserts. The I/O table should (and does) account for this reality. The I/O accounting problem hinges on how this secondary output is handled. Although almost any solution is likely to be imperfect, the SNA approach adopted by BEA is more straightforward than most.

Earlier Treatment of Secondary Output

Previously, BEA analysts redefined some secondary output; that is, they excluded secondary activities

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[1] U.S. Department of Commerce. *Survey of Current Business*. Vol. 59, No. 2. Bur. Econ. Anal., Feb. 1979.

[2] United Nations. *A System of National Accounts*. (Proposals for the Revision of the SNA 1952, E.CN.3/320, Econ. and Social Council, Feb. 1965, mimeog.

[3] United Nations. *A System of National Accounts*. ST/STAT/SER.-F/SREV.3, Dept. Econ. and Social Affairs, N.Y., 1968.

[4] At the risk of oversimplifying, we consume commodities and industries produce them. Thus, persons analyzing demand often use commodity data, and persons analyzing supply response use industry data.

and associated inputs from the producing industry and included them in the primary industry. All other secondary output was transferred; it was treated as though the producing industry sold it to the primary industry, thus adding to the primary industry's output.

Basically, this procedure allowed the outputs to appear in a single sector. However, the secondary transfers were counted twice, as outputs of the producing and receiving industries. The producing industry's distribution of its output to customers was distorted, as was the receiving industry's composition of inputs. In other words, the ice cream produced by fluid milk processors showed up in the published table as a sale from Fluid Milk to Ice Cream processors. Fluid milk purchased as an input for ice cream production would be included in this published transaction as would the value of ice cream produced by fluid milk processors. This reporting distorts statistics on both the sales distribution of fluid milk processors and also the input composition of the ice cream processors. The treatment of secondary products in BEA's 1972 I/O tables eliminates most of these difficulties.

A Graphic Illustration of SNA Changes

To further explain the SNA approach used in the 1972 table, consider a set of production accounts in the following table.

Flows	Commodities	Industries	Final demand	
Commodities		U	f	q
Industries	V			g
Value added		y'		η
	q'	g'	η	

Note: A capital letter denotes a matrix, a small letter denotes a column vector, a small greek letter denotes a scalar, and a ' denotes a transposed vector. Rows read across and columns read down.

The matrix U in the table has commodities in the rows and industries in the columns. Thus, it is a commodity-by-industry matrix. Its typical elements in a row j and a column k shows the amount of commodity j used up in production by industry k. The matrix U is sometimes called an absorption (or use) matrix as the row shows how commodities are "absorbed" as intermediate inputs by industries (the elements of U). The row sums of this matrix represent the total industrial intermediate use of commodities; the column sums represent the intermediate use of commodities by industries.

If one assumes that intermediate inputs of commodities are proportional to the industry outputs into which they enter, then:

$$U = B\hat{g}, \text{ or} \qquad (1)$$

$$B = U\hat{g}^{-1} \qquad (2)$$

where a circumflex (ˆ) over the symbol indicates that elements of that vector are spread out to form a diagonal matrix. The superscript −1 represents a matrix inversion. Thus $\hat{g}^{-1}$ denotes a diagonal matrix of the reciprocals of industry outputs. Equation (2) shows that commodity inputs are required in fixed proportions by each industry. The columns of matrix B give these fixed input requirements.

The matrix V in the table has industries in the rows and commodities in the columns. This "make" matrix tells in which industry each commodity was made:

$$D = V\hat{q}^{-1} \qquad (3)$$

Equation (3) states that commodities are produced in fixed proportions by the industries that make them. The columns of matrix D give these fixed market shares. If we post-multiply the commodity-by-industry direct requirements matrix, B, from equation (2) by this fixed-market shares matrix D, we gain a new direct requirements matrix. In this matrix, B's coefficients, interpreted as direct input requirements of commodity i per dollar of output in industry j, have been reweighted by D's fixed-market shares. As a result, the coefficients of the product, BD, become direct input requirements of commodity i per dollar of output of commodity j. BD is now a commodity-by-commodity direct requirements matrix.[5] Thus:

$$q = (I\text{-}BD)^{-1}f \qquad (4)$$

[5] The matrix multiplication used to estimate this direct requirements matrix assumes that all products (primary and secondary) of an industry have the same input requirements: this is the industry technology assumption. In an alternate approach called the commodity technology assumption, production of a commodity requires the same mix and proportions of inputs regardless of which industry produces it.

In our ice cream example, under the first assumption, the estimate of inputs required to produce ice cream in the fluid milk industry, and thus the inputs transferred, would be proportional to the inputs into the entire fluid milk industry. With the other assumption, a separate input

In this equation, q is a vector of domestic commodity outputs, f is a vector of final demands for commodities, and $(I\text{-}BD)^{-1}$ is a commodity-by-commodity total requirements matrix. The terms in $(I\text{-}BD)^{-1}$ are the total requirements for output of commodity i per dollar of final demand for commodity j.

Reweighting this total requirements matrix by premultiplying with the fixed-market share matrix again converts the terms. After this operation, the terms in the matrix $D(I\text{-}BD)^{-1}$ become the total requirements for the output of industry i per dollar of final demand for commodity j. $D(I\text{-}BD)^{-1}$ is now an industry-by-commodity total requirements matrix:

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cost structure for ice cream production would be estimated and used in transferring the secondary production of ice cream from the fluid milk industry to the ice cream manufacturing sector.

In Earlier Issues

The use of electricity on farms is still in its infancy. . . . On most farms electricity seeps rather than surges into the farm organization. A farmer first has lights in the service buildings and service areas. A little later he installs something more—possibly an electrically operated pump jack—then a tool grinder—then a chick brooder—and so on. The effect of each individual use may be too small to measure accurately but the aggregate effect of all of them is decidedly significant on many farms. Electric power clearly has been instrumental in reducing labor requirements in American agriculture.

Joe F. Davis
July 1951, Vol. 3, No. 3, p. 86

Dr. Nourse is concerned first of all with what may be termed "groupism"—the tendency of organized agriculture, labor, and industry to make demands which, if granted, are certain to be detrimental to the economy as a whole. Second, he is concerned with the tendency, not only of these particular groups, but of people generally, to demand from the economy, in the name of security, more than they are willing to contribute. Third, he is concerned that excessive demands in the guise of military preparedness will result in an over-commitment of the Nation's industrial system and in the imposition of oppressive controls. Finally, he is concerned that, instead of rejecting excessive demands, an attempt will be made to meet them through a continuous process of general inflation that will seriously undermine the basic strength of the economy.

James P. Cavin (Review of: *The 1950's Come First* by Edwin G. Nourse)
July 1951, Vol. 3, No. 3, p. 104

$$g = D\,(I\text{-}BD)^{-1}f \qquad (5)$$

In summary, the national accounting approach allows the BEA to handle mechanically the problem of transferring secondary output of industries without double counting. The two crucial assumptions are that industry technology prevails (B) and fixed-market shares exist for industries producing each commodity (D). Obviously, the validity of these assumptions varies among sectors.

If a separate cost structure had been available for each commodity produced by each industry included in the table, the transfers could have been made manually by simple addition. Lacking these cost data, BEA judged the mechanical method based on matrix manipulations to be the best alternative. In many instances, the industry technology assumptions were clearly inappropriate, and the secondary output was redefined (shifted) to the primary industry manually.[6]

In the table the value added row would include all the value added originating in an industry. To this subtotal, one would need to add the amount of the product originating in government and households to get gross domestic product. To this total, to get gross national product, one would also add the amount of net product originating in the rest of the world; that is, wage, interest, or other factor income earned by or accruing to U.S. residents from foreign economic activity, less corresponding amounts accruing to foreigners from U.S. economic activity. BEA achieves this result by defining special industries in the intermediate sectors for the income originating in households, government, and the rest of the world.[7]

[6] The six most important instances were: construction performed within industries by these industries, manufacturing done within the trade and service sectors, retail trade in service sectors, wholesale sales of purchased goods by manufacturers (resales), rental activities of all industries, and electricity produced and sold by mining and manufacturing industries and railroads.

OTHER CHANGES IN I/O PRESENTATION

A second major change, this one independent of the national accounting approach, occurred in presentation of the 1972 I/O data. The transactions table carries domestic output data instead of total output data. Competitive imports, imports with a domestic counterpart which to an extent compete with domestic production, now appear as a negative entry in final demand in the row of the comparable domestic producer rather than as a row of transferred imports. When they were in the transferred imports row, they were treated as inputs into the comparable domestic industry. This change reflects the increasing importance of imports to the U.S. economy.

[7] This procedure permits the value-added row to reflect GNP without having final demand purchases in the value-added row.

In addition, two dummy industries, office supplies and business travel and entertainment expenditures, were eliminated in the 1972 table. Allocations for these expenditures are now made directly from their producing industries. A new industry was added—eating and drinking places—which had been included in retail trade. The shift occurred because this activity differs from other retail trade; retail traders ordinarily buy and sell goods without changing their form, whereas eating and drinking places transform ingredients into prepared foods and beverages.

IMPLICATIONS

For agricultural economists, these changes in the national I/O tables should make I/O more useful in economic analysis. The conceptual basis for the table has been made more explicit and its use extended by the new handling of secondary products and the publication of related data. The shift to a domestic output base makes it easier to analyze the impacts of agricultural trade because competitive imports are now exogenous. The separate eating and drinking sector provides new opportunities for research.

Few advancements have no costs, however. Analysts who choose to use a level of detail other than the levels now published by BEA must calculate their own direct and total requirement matrixes. To do so, they must also rewrite their matrix manipulation routines.

AGRICULTURAL SECTOR PLANNING: A GENERAL SYSTEM SIMULATION APPROACH

George E. Rossmiller, editor, Department of Agricultural Economics, Michigan State University, East Lansing, 1978, 430 pages, $8.

*Reviewed by Reuben N. Weisz**

Sixteen analysts from various disciplines who worked together during 1971-77 to develop, install, and use a general system simulation approach to agricultural planning in the Republic of Korea present a case study of their efforts in this book. As they describe the approach: "It facilitates and depends on strong and continuous interaction among administrators, investigators and affected people, as participants in the decision-making process. It is eclectic with respect to philosophies, data and information sources and types, model types, the use and nonuse of various maximizing techniques, assumptions, and dimensions" (p. 42).

In part I, "The Case Study Projects," the authors describe the historical, bureaucratic, and institutional working environment which shaped their point of view as they conducted their research for a specific clientele—government planners. It is possible, they state, and often highly desirable, to develop decision-making systems within the public sector that include the capacity to analyze and monitor through use of computer-based models. Their argument will contribute to the current debates between proponents and opponents of modeling in general, between advocates and antagonists of the methodology used here, as well as to the controversy between supporters and critics of the use of models in economic development.

"Improving Agricultural Decision Making," chapter 1 in part II, describes how decisions are made in agricultural development. Disciplinary, subject-matter, and problem-solving models compliment one another as they bring normative, positive, and prescriptive knowledge together for decisionmakers.[1] The general systems simulation approach —a means, not an end—can help people make decisions. If this approach enables decisionmakers to find better solutions to problems than they could have obtained with other modeling strategies, the approach can be deemed good, the authors state. "The proof of the pudding is in the eating." The reader who is used to more traditional criteria for evaluating models (*t*-statistics, R^2, number of turning points missed, and so on) may have a difficult time accepting the authors' simpler method of evaluation.

Initially, chapter 2, "Values and Policy Choices in Agricultural Development," appears to be a superfluous philosophical discussion. However, the authors make important points:

1. Policy choices must be specified before policy instruments (price controls, tax policies, and so on) can be defined as decision variables in the model.
2. Values must be specified before performance indicators (measuring balance of trade, employment, nutrition, and others) can be specified as output variables in the model.
3. The relationships within the agricultural sector, as well as between it and the rest of the economy and environment must be set out before they can be used to define relationships between policy variables and performance indicators.

"Theory and Practice of Model Building and Simulation," the concluding chapter in part II, digests conventional wisdom on the subject. The approach adopted in the study consists of a system built of regularly interacting parts. These building blocks may also be systems. Breaking down the overall research problem into these components reduces the complexity and magnitude of the problem. This process allows for a division of labor; each member of the research team is assigned to a component which corresponds to that researcher's training and experience. Eventually, connection of the individual components forms the general systems simulation model.

KASM, the Korean Agricultural Sector Model System presented in part III, contains five components:

1. population
2. national economy
3. technological change
4. resource allocation and production
5. demand, price, and trade

The authors give the data requirements and parameter estimation procedures, and they present applications of the general model and its individual components.

Part IV, "The Korean Grain Subsector Models," describes two smaller KASM modeling efforts related to grain management programs. Part V,

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[1] Normative refers to concepts of values; positive, to information about conditions, situations, or things not pertaining to their goodness and badness; prescriptive, relates the positive to the normative (pp. 36-37).

"Technology Transfer," focuses on the problems, requirements, and processes of incorporating the systems simulation approach into the decisionmaking structure of developing (or developed) countries. Some critics may not believe the Korean technology can be transferred to other countries.

I disagree. Although a few of the lessons learned are uniquely Korean, much of the knowledge could apply elsewhere. Many of the authors' ideas correspond to current ESCS research activities as reported on in the July 1978 issue of this *Journal*. For example, a compatible set of user-oriented systems (that can be used individually, interchangeably and/or interactively, depending on analysts' needs) underpins the design of the OASIS software. Also, the concept of viewing software as capital stock is imbedded in the LAWREMS library of data sets and models. Finally, the concept of transferring and institutionalizing modeling technology to developing countries is built into the CRIES system.

One of the advantages of the building block approach is that the model builder can draw on existing archetypes of models when designing individual components of the general model. Examples in KASM of archetypes include a standard cohort survival model (used in the population component), an input/output model (used in the national economy component), and a linear programming model (used in the resource allocation component). However, the use of archetypes may disappoint readers who are looking for innovative methodological breakthroughs.

The general systems simulation approach has been successfully used in other subject matter areas. However, the authors merit recognition and praise for being the first to successfully introduce the methodology into agricultural sector planning on such a massive, complex, and formal scale.

Any attempt to put together a multiple-author manuscript on the systems simulation approach may be fraught with the same problems encountered when applying the multiple-modeling approach to the decisionmaking process, such as, gaps, overlaps, and inconsistencies among components and chapters. However, the editor and authors have done an outstanding job in putting together a well-written exposition of this complex subject.

If a few more books such as this one were published, agricultural economics could be called the "interesting science." After applying the same criteria to this manuscript that the authors use to evaluate models (coherence, correspondence, clarity, and workability), I must rank this book among the best produced in 1978. I have not reviewed the $40, 1,200 page, six-volume technical documentation on the KASM system. But this shorter version should prove to be a standard reference that will reduce the credibility gap between the systems simulation true believers and agnostics.

In Earlier Issues

Agricultural price analysis was one of the hard cores around which the agricultural economics of the 1920's and early 1930's were built. Since then, in all too many cases the working economists have been too busily engaged in current operations to set down their appraisals of price-making forces in any formal way. Many have drifted from recognized statistical methods to a shorter-run, almost wholly intuitive, "market feel" approach. Some of the theoretical or teaching economists, especially the mathematically trained group, have gone in the opposite direction, stressing models, structural equations, and the substitution of symbols for statistics.

O. V. Wells
July 1951, Vol. 3, No. 3, p. 65

RURAL U.S.A.: PERSISTENCE AND CHANGE

Ford, Thomas R., editor, Iowa State University Press, Ames, Iowa, 1978, 208 pages, $9.95.

*Reviewed by Leslie Whitener Smith**

An underlying theme runs through this collection of 13 essays on rural society: continued cultural pluralism and diversity and the persistence of characteristics, attitudes, and behavior which have traditionally distinguished rural people from their urban counterparts. *Rural U.S.A.*, more than any other recent book, should end any lingering belief in the "mass society perspective" prevalent in the sociological literature of the sixties and early seventies.

For the last 50 years, proponents of this mass perspective have advanced the idea that social and technological developments in the United States had leveled all cultural differences between rural and urban people to create a sociocultural homogeneity across society. This notion has not been empirically substantiated. As Ford notes in his overview, "little in the available evidence indicates an early extinction of traditional [rural-urban] disparities." This persistence is not surprising to those following the ecological perspective and who believe that environment shapes the social and cultural patterns of an area. Ford explains that as long as the environmental milieux of the city and the country differ, rural-urban differences will continue. These ideas pervade the book. Yet, unfortunately, *Rural U.S.A.* will probably not end the controversy over the existence and relevance of the rural-urban distinction. The debate will continue, despite these authors' efforts to emphasize that explaining persisting rural attitudes, values, and behavior is as important as interpreting change and development.

Commissioned by the Rural Sociological Society (RSS), *Rural U.S.A.* examines persistence and change in rural America. The book was designed as an update to the earlier RSS-sponsored publication.[1] Contributors include demographers and rural sociologists from the Federal Government, universities, and private organizations concerned with rural affairs.

In organizing the book, Ford uses the ecological perspective as an analytical framework and emphasizes the effects of environment on the development and structure of rural culture. A close reading of his overview chapter is a "must" for understanding his organizational scheme. Essays in parts II and III focus on the rural habitat and characteristics of the population. Other sections examine the changing rural environment and its effect on human cultural adaptation, defined traditionally in terms of technological systems (part IV); value and normative systems (part V); and social organization systems (part VI). Part VII departs from the ecological framework to discuss the future of rural society. Wilkening and Klessig, describing changes in the rural habitat, emphasize the serious environmental concerns over pollution and land misuse resulting from the rapid and increased demand for food, energy sources, and recreational space. Beale's article builds on their treatment by depicting the recent reversal in the traditional rural-to-urban migration flow and the substantial population growth experienced by nonmetropolitan areas. Brown and Zuiches' essay on the changing characteristics of the rural population complements Beale's analysis.

Bertrand's essay focuses on human cultural adjustment to environmental changes—both the positive and negative aspects of new technologies, highly commercialized agriculture, and increasing rural industrialization. Larson, examining the value and normative structure of rural society, reverses his earlier position. He concludes that rural-urban differences in attitudes, beliefs, and values are not diminishing over time, clearly challenging the mass society perspective.

Additional chapters examine the socio-organizational structure of rural society and the persistence of traditional problems associated with minority status, sex, and rural poverty. Wilkinson considers difficulties experienced by rural communities that must adjust to the changing agricultural economy. Rainey and Rainey look at problems of meeting increased demand for public services within the community that lacks adequate finances or supporting government structure. While rural minorities have made some economic gains over the past few decades, Blacks, Hispanics, and especially American Indians, still suffer from discrimination and poverty, conclude Durant and Knowlton. In their somewhat speculative article, Flora and Johnson note that rural women face similar economic problems. They conclude that part of the reason for rural sexual inequality derives from the more traditional values and role

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[1] James H. Copp, editor. *Our Changing Rural Society: Perspectives and Trends.* Iowa State University Press, Ames, Iowa, 1964.

attitudes of rural women. Chadwick and Bahr present a more than adequate picture of rural poverty using 1970 Census data, although more current economic statistics are available for analysis.

Authors of essays in the concluding chapters attempt to predict the future state of rural society. Schaller notes that national rural policy will undoubtedly change its traditional focus from a commercial agricultural policy to a two-pronged approach emphasizing food and rural development strategies. Coughenour and Busch show us two scenarios: the first predicts a more varied and complex way of life, but one still based on the distinct and fundamental values of rural life; the second envisions a society based on a decentralized organizational structure and rational planning at the community level. Clearly these two scenarios are speculative; as Ford notes, "social scientists are not soothsayers." Nevertheless, they suggest plausible, markedly optimistic alternatives.

While *Rural U.S.A.* may not become a classic in the rural sociological literature, it certainly more than adequately samples the recent contributions of rural sociologists and the issues of concern to rural society. Ford's organizational scheme becomes somewhat lost as one reads each individual essay. However, each essay's concern with aspects of the rural renaissance and the implications for the structural organization of rural society helps to tie the essays together.

It is particularly interesting to compare *Rural U.S.A.* with its predecessor, *Changing Rural Society*, to observe shifting areas of emphasis over time. *Rural U.S.A.* shows an increased interest in the problems of rural women and racial/ethnic minorities—problems that clearly require additional research—and perhaps less interest in the changing structure of agriculture and the problems of farm-related people. No volume of readings can adequately cover all relevant, important issues facing members of rural society. Yet one sorely misses treatment of the changing rural family, quality of life, problems of rural youth and the aged, and the sociology of rural leisure. Additionally, although the book is designed to focus only on rural America, some attention to trends and conditions in rural society throughout the world would have been welcome. Far too often, readers and handbooks on rural development neglect the international and Third World perspectives.

In general, this book presents a current analysis of rural society in America. The authors examine change and persistence and they briefly identify important issues and concepts for future research. The book clearly represents a useful compendium.

In Earlier Issues

. . . a handful of statisticians, a few agricultural economists, and a few general economists, especially Keynes, have gone far toward bringing about a revolution in both economic theory and its application to current problems within the United States over the past 25 years or so. This thesis would rest not so much upon various theories which have been advanced but rather upon the concern of the statisticians, the agricultural economists, and equally Keynes, with the interweaving of economics and the problems of real life, with the endeavor not only to measure what was happening but also to relate the various facts to each other and fit them into some meaningful and useful framework.

O. V. Wells (Review of: *Economics with Applications to Agriculture* by Edwin F. Dummeier, Richard B. Heflebower, and Theodore Norman)
July 1951, Vol. 3, No. 3, p. 105

Dams, Theodor and Kenneth E. Hunt, editors, University of Nebraska Press, Lincoln, Nebr., and London, England, 1977, xiii and 603 pages, $21.50.

*Reviewed by G. Edward Schuh**

Proceedings of the sixteenth international conference of agricultural economists held in Nairobi, Kenya, in mid-1976, report on the central conference theme: decisionmaking and agriculture. As proceedings go, this one is unusual. The papers are meaty, provocative, well-edited, and readable.

Because of rising printing costs, the International Association of Agricultural Economists now publishes only summaries, not verbatim transcripts, of the general discussion at plenary sessions. Professor K. E. Hunt, Director of the Agricultural Economics Institute, University of Oxford, England, prepared these from written statements provided by speakers and from the taped record of the proceedings. Generally, these summaries are followed by concluding remarks of the readers of the main papers. This procedure has much to recommend it. We also are much indebted to Professor Hunt for putting the proceedings into their excellent final form.[1]

Of special note at this conference was the establishment of the Leonard Knight Elmhurst Memorial Lecture in memory of the Association's founder and president. Professor Theodore W. Schultz presented the first lecture in this proposed series: "On Economics, Agriculture, and the Political Economy." In this penetrating lecture, Schultz calls our attention to government's role in affecting the economic performance of agriculture and challenges economists to evaluate the economic effects of what governments do to agriculture. He notes the increasing opposition to economics in social and political thought, the debasement of economics by governments, and the unwillingness or inability of economists to challenge this adverse drift. He further warns us as professionals not to take the particular economic goals of governments as given, lest economies become hostage to government. As part of this salvo, he notes that agricultural economists are not known for their critical evaluations of the economic effects of various political institutions on agriculture.

While appropriate to the U.S. scene, this last criticism seems somewhat misplaced for agricultural economists in other countries. In Latin America particularly, professionals who identify themselves as agricultural economists provide ample challenges to the political institutions. Professionals in other low-income countries also challenge these institutions. Regrettably, economists from these countries were sadly underrepresented on the conference program—a point to which I will return below.

Characterizing the papers as a whole is not an easy task. For the most part it is a high-quality volume, with papers addressing a wide range of the various aspects of decision-making in agriculture. Perhaps most disappointing is the lack of research content, a point noted by Denis Britton in his synoptic view of the conference included in the volume. This undoubtedly reflects the fact that the volume contains only material from the plenary sessions, and plenary sessions generally are designed to appeal to a broad audience. However, it also may reflect the subject-matter theme of the conference, in contrast to one in which alternative solutions are posed.

This reviewer was struck by the lack of relevance of most of the papers to the burning issues of the day: (1) the North-South debate emphasizing international commodity markets and how well they work; (2) the challenge of feeding a world population that is expected to double in approximately 25 years; (3) the continued prevalence of poverty among most of the world's population, particularly among rural people; and (4) growing agricultural trade problems that create international political difficulties and distort domestic agricultural policies. One questions whether papers with high research content on such issues would not merit plenary interest.

Britton questions whether our large institutions such as the World Bank are still learning more by trial and error than by systematic research. If the papers in this volume truly reflect our profession's state of the art, the answer is most assuredly yes. But if that judgment is valid, then an important part of the next confer-

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[1] Only activities of the plenary session appear. A symposium on Kenyan agriculture was also held during the conference, and a special volume has been published as the introduction to that symposium. A day was devoted to food and population programs and the Association expects to publish the papers. The 24 contributed papers read at the conference have been published as the first of the new series of IAAE Occasional Papers.

Yet for our profession to contribute to the solution of the important problems before us, we need to address them more directly and be more willing to confront alternative perspectives in considering them.

ence might well be addressed to identifying world agricultural problems and to developing strategies for solutions.

The geo-political mix of persons invited to present papers may explain in part this failure to address important world problems. Of the 36 major papers, 17 were given by people from the advanced, market economy countries, 8 by people from centrally planned countries, and 9 by people from low-income countries. (Two papers did not identify the authors' countries.) For discussants, the bias was even more severe. No less than 33 came from advanced, market-economy countries; only 3 represented centrally planned countries; and 9 were from low-income countries.

This distribution of speakers may reflect the membership rolls of the Association. If so, legitimate questions can be raised as to whether membership in the Association is an appropriate criterion for selection. A more likely hypothesis, however, is that, consciously or not, members have wanted to keep the meetings from being politicized. This hypothesis is consistent with the rather neutral, subject-matter content of the conference theme, and with the lack of critics from the Third World and the centrally-planned economies on the program. Although such an approach obviously makes for less controversy, it also fails to use our analytical tools and insights in addressing the major issues of the day.

Developing a program for an international conference is not easy. The sheer task of knowing who is doing what is enormous, and the conflicting goals of various interest groups leads to compromise that can be stultifying. Professor Theodor Dams of the University of Freiburg, Federal Republic of Germany, who developed the program, and the others who organized the 1976 conference are to be commended for the generally high quality of the papers. Yet for our profession to contribute to the solution of the important problems before us, we need to address them more directly and be more willing to confront alternative perspectives in considering them.

The 36 papers in the volume cover such topics as economics, agriculture, and the political economy (Theodore W. Schultz, U.S.); the contribution of economists to agricultural policymaking (Glenn L. Johnson, U.S.); the role of models in agricultural decisions (Michael Petit, France); farm-level decision models (R. A. Richardson and others, Australia); regional and interregional planning models (Joseph Sebestyén, Hungary); agriculture and national economic policy (Kazushi Ohkawa, Japan); agricultural and economic policies under socialism (Augustyn Wos and Zdzislaw Grochowski, Poland); agricultural policy in India (M. L. Dantwala, India); and optimum pricing and marketing strategies in rural development (Uma Lele, World Bank). The presidential address on the conference theme was delivered by Samar R. Sen.

In Earlier Issues

The essence of economic progress is the orderly and continuous adaptation of the use of productive resources to changing conditions of production and demand.

Robert B. Glasgow
(Review of: *Agricultural Progress in the Cotton Belt Since 1920* by John Leonard Fulmer)
April 1951, Vol. 3, No. 2, p. 63

Marshall Jevons. Thomas Horton and Daughters, Glen Ridge, New Jersey 1978, 168 pages. $7.95.

*Reviewed by William E. Kost**

"Now let's get this straight, Professor. You think you know who the murderer is based on economic theory?"

"I am sure of it," Henry Spearman replied.

With a jacket blurb quote like that, I couldn't resist buying this book. The combination of a new application of my professional interests plus the economist as hero was too much to resist.

My microeconomic theory professor in graduate school once said that if he was a successful economics teacher, his students would find themselves applying economic principles to all their decisions in life; not just to economic decisions. I was, at first, skeptical, but later came around to doing just that. I now know who he studied under—Professor Henry Spearman.

Spearman provides a perfect role model of success and status for economists. He is a full professor at Harvard, a successful lecturer, columnist, and author, as well as a recipient of a Harvard distinguished teaching award. On top of all this, he is the living example of the economists' economic man—one who is well aware of microeconomics and opportunity cost concepts and makes all his personal decisions based on an analysis of his utility surface and on applications of marginal analysis. He believes that economics is best defined as the study of mankind as it goes about its ordinary business of existence. As a student and teacher of economics he is continually amazed at how regularly and consistently the "laws" of economics can be observed in real life. Professor Spearman delights in observing the ordinary daily economic behavior of his fellow humans.

It is just such behavior that involves him in racial unrest, murder, and intrigue on what was originally planned as a quiet vacation in the Virgin Islands. Can he apply the tools of economics to the dismal events that occur at a plush Caribbean resort? Spearman says, "I'm sure of it." And he is right. You will be amazed at the logical deductions Professor Spearman draws by applying the "immutable" laws of economics to both the quite ordinary and extraordinary behavior of his fellow guests at Cinnamon Bay.

Observing peoples' behavior with the proper perspective explains many things. The proper perspective, of course, includes profit maximizing criteria, opportunity cost analysis, supply-demand analysis, capital theory, and game theory. With the proper perspective, solving the mystery does become elementary—elementary economics, that is. With his deductive powers and economic way of thinking, Professor Henry Spearman could join Rabbi Small in providing a new dimension to murder mysteries.

If you are an economist, you will find this book great fun. In real life, the professor might come across as somewhat of a bore. The economic way of thinking, while being a good way to make decisions, is a bit much when it enters into all conversations.

This narrow focus characterizes everyone in the book, not just Spearman. All are one dimensional. Each views the world solely from a perspective based on the precepts of his or her profession. In one sense this bias causes the characters to seem shallow and unrealistic. In another sense, it heightens the sense of satire. I would guess we all view the world with our own biased visions.

*The reviewer is an agricultural economist in the Foreign Demand and Competition Division, ESCS.

In Earlier Issues

. . . scientists have worked wonders in solving natural limitations and opening new opportunities. But such success can make us too optimistic, for there is no substitute for natural resources as a whole, and there are limits to which one resource can be substituted for another.

H. H. Wooten (Review of: *American Resources; Their Management and Conservation* by J. Russell Whitaker and Edward A. Ackerman)
July 1951, Vol. 3, No. 3, p. 108

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